# MOTOR BODIES AND CHASSIS

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# MOTOR BODIES AND CHASSIS

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## A TEXT-BOOK DEALING WITH THE COMPLETE CAR, FOR THE USE OF OWNERS, STUDENTS, AND OTHERS

BY

H. J. BUTLER

TECHNICAL EDITOR OF "THE AUTOMOBILE AND CARRIAGE BUILDERS' JOURNAL"
HONOURS SILVER MEDALLIST AND IST PRIZEMAN CITY
AND GUILDS OF LONDON INSTITUTE

FOREWORD

BY THE

RT. HON. THE LORD MONTAGU OF BEAULIEU

EDITOR OF "THE CAR ILLUSTRATED"

NEW YORK

D. VAN NOSTRAND COMPANY

23 MURRAY AND 27 WARREN STREETS

1912

656.3
B97m

# FOREWORD

BY THE

RT. HON. THE LORD MONTAGU OF BEAULIEU,

EDITOR OF "THE CAR ILLUSTRATED."

MR. H. J. BUTLER has in the following pages stated so much that is interesting, both to the motorist, the carriage builder, and the manufacturers of the chassis of the automobile, that any praise or criticism in detail is unnecessary. The author is a thorough master of his subject, and has had many years of training in the matters with which he deals.

There was a time when the buyer of a motor car was interested chiefly in the machinery, and was wont to talk learnedly, or the reverse, about the details of the engine and gear, which in those days were all-important, for they were by no means reliable. But the more reliable the motor car engine became, the less consideration had to be given by the would-be purchaser to this part of the subject. Speaking generally in this year 1912, n ost of the leading British and Foreign makers construct cars of proved reliability, and a mechanical breakdown on the road in the case of a first-class private car has become quite rare.

Thus it follows that the carriage builder has come to his own once more, and it is natural that the would-be purchaser, male or female—and the ladies are, by the by, the more critical—should be devoting a great deal more attention than formerly to the design of the body work, the comfort of the interior, and to the fittings and the coach-work generally. The horse-carriage builders who some twelve years ago thought themselves about to be ruined when the motor car was first introduced, and when the use of the horse carriage began therefore to decline, have found an unexpectedly large and growing market in which, although there is much competition, there is plenty of work for all, and likely to be even more in the near future.

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It is curious that the money which the buyer will spend on a good body for a motor-car is now quite as much, if not more, than that which used to be spent on a similar body for a horse-drawn carriage in the past. To-day also, as formerly, one can state without contradiction that the carriage work of British manufacturers is still superior to that made anywhere else.

There is no point about motor body and chassis that Mr. Butler has neglected, and it is with real pleasure that I commend this book to brother and sister motorists, to the students and workmen of his own trade, and to the public generally. There are certain points in which the author's common sense, and his knowledge of the latest developments, are particularly shown; such as the fact that in none of his illustrations are the side doors drawn as being hung in any but the right way, that is hinged from the front, instead of from the back, following railway practice, so that if the car happened to go on with the door open the tendency of forward motion will help to close the door. He also realises the necessity for protection from the elements, and he devotes special attention to screens and hoods. He also puts in a plea for the proper treatment of the body with good paint, and emphasises that plenty of time ought to be allowed for the outside and final coat of varnish to dry, a period which is generally cut too short, owing to the anxiety of the owner to have his motor-car for use on the road as soon as possible.

As Mr. Butler is the technical editor of *The Automobile and Carriage Builders' Journal*, there is no wonder that he speaks with authority to the chassis builder and body builder, and puts forward in their right proportions the claims due to each in the production of the perfect motor-car.

The chapters on the petrol engine and the machinery of the chassis itself are well worthy of attention, and the notes on the preservation of a car should be read by every motor owner and motor man, whether amateur or professional, who desires to maintain a car in good order.

Mr. Butler deserves a great success with his book, and I hope that he will achieve it.

"The Car" Office,
168, Piccadilly,

# PREFACE

So far the many books dealing with the subject of motor cars, which have been published, have dealt almost exclusively with the engineer's portion of it, that is, the chassis, giving but slight heed to the bodywork. This book is intended as an introduction to the study of the complete car, and as much importance is attached to the art of the carriage builder as to that of the motor manufacturer. Now that the design of the mechanism is confined largely to the improvement of small details, more notice has naturally been directed to the body, and the author feels that an opportune moment has arrived for placing at the disposal of those interested more information regarding this part of the car. By so doing it is hoped that the motorist will be in a better position to choose the body best suited to his needs, while the student is provided with a text-book, part of which comprises subject-matter which has hitherto been unavailable.

The treatment of the various chapters has been carried out as broadly as possible, but here and there interesting deviations from standard practice have been described. The various styles of bodies are dealt with fully from the point of view of the user, constructor, and draughtsman. The painting and upholstery, as well as the more important accessories, receive their share of attention.

Regarding the chassis, the path of the fuel from the tank to the silencer is followed, the various parts and working principles being treated in their natural order; but separate chapters are devoted to ignition, the cooling of the cylinders,

and lubrication. In dealing with ignition, the object in view has been to lead up to the subject of the high tension magneto system rather than to consider it exclusively. The chapter on wheels includes the survey of both wood and metal types as well as modern detachable devices, while the matter of tyres is gone into fully, since it is so closely bound up with the financial side of motoring, a point of view enlarged upon in the last two chapters, which deal with the cost of running both pleasure and commercial cars.

Acknowledgment is due to those British and American firms who have supplied particulars of their cars, and to those makers of components and accessories for information regarding their specialities. The author expresses his indebtedness to those carriage builders who supplied material from which the tables in Chapter X. have been compiled, and for the knowledge gained by the perusal of the motor press generally since the inception of automobilism.

H. J. BUTLER.

Bush Hill Park,
Enfield.

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# MOTOR BODIES AND CHASSIS

## CHAPTER I

### *THE VARIETIES OF MOTOR BODIES DEFINED*

THERE are twenty or more varieties of motor bodies, some of which have been directly adapted from horse-carriage styles. A body is named according to its general outline, seating capacity, and arrangement, and whether open or closed, or a combination of these last two features. One body may also differ from another

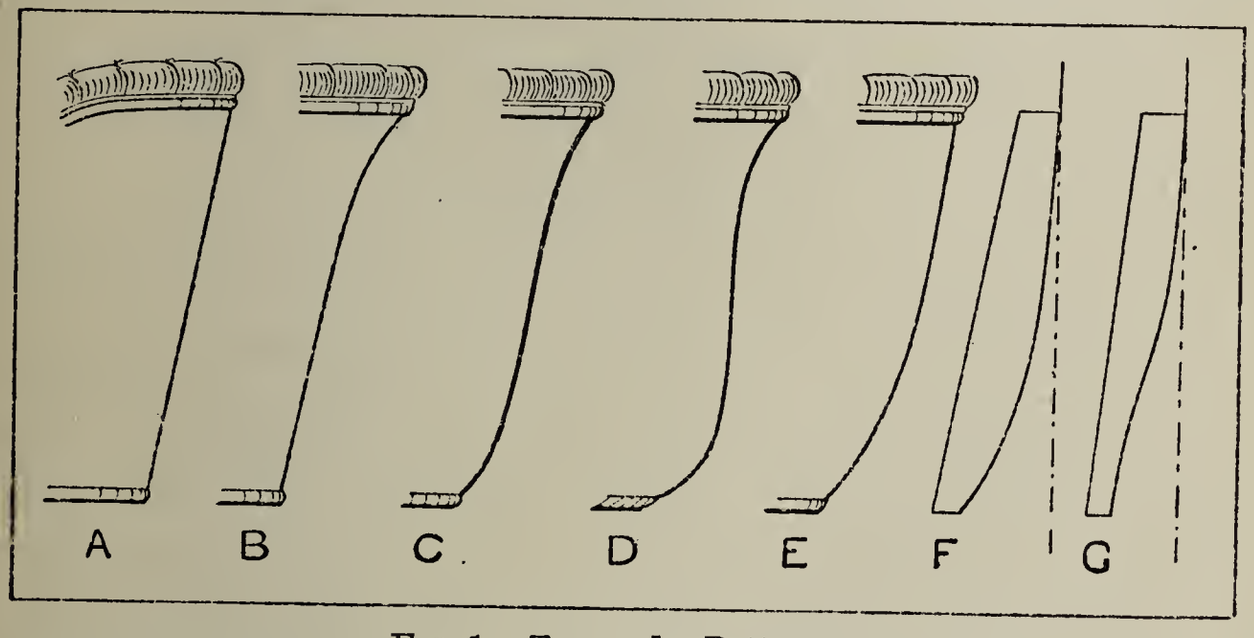


FIG. 1.—Turnunder Patterns.

A. Straight or plain.
B. Tulip.
C. *Roi des Belges* (a good example).
D. *Roi des Belges* (bad exaggerated type).
E. Rotund.
F. Rotund sweep, as applied to a door panel.
G. Return sweep, as applied to a door panel. The dotted line is the square line, and shows how the amount of turnunder is decided.

according to its turnunder pattern, that is, the shape of the panels on a vertical section. The turnunder may be *straight* or plain,

when it is an inclined line; *rotund*, a curve with fulness at the bottom; *tulip*, a curve with fulness at the top, and the opposite to rotund; and *Roi des Belges*, a return curve combining both the last two turnunder patterns, the tulip curve being at the top. All these styles are usually associated with the turnunder between the elbow and the seat line, or, in a full-panelled body, between the elbow line and chassis. The *ogee* turnunder is a reversal of the *Roi des Belges* return curve, the latter without doubt being evolved from the former, as it is usually adopted in a modified form in horsed landaus for the turnunder of the doorway, and is used in many limousines and landaulettes to-day. The turnunder of the

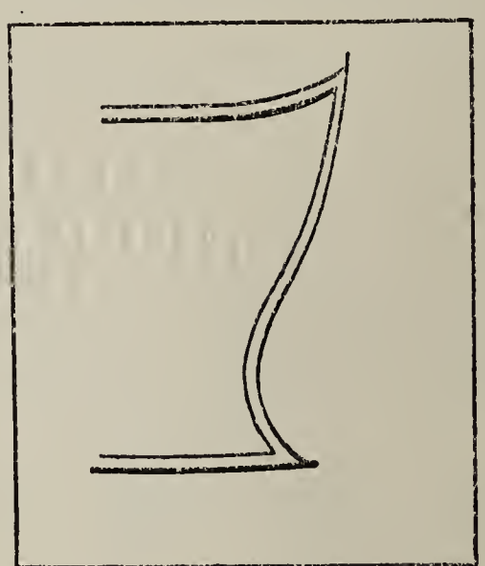

Fig. 2.—Ogee Turnunder.

doorway is usually a rotund sweep, in all types of bodies of normal width.

(1) *Two-seated Cars, or Single Phaetons.*—These have a driving seat only, which may be a single seat with or without a central division, or consist of two separate bucket seats. Side doors and wind screen are fitted to all modern types, and there is generally a cape cart or leather hood. The portion behind the seats consists of a large locker opening from the top. Racing cars are low-built single phaetons.

(2) *Three-seated Cars.*—A large number of two-seated cars are fitted with a fixed or collapsible single seat at the rear, and the hind locker forms a convenient place in which to fold this seat when not required. In some earlier types of chassis, owing to the different disposition of the engine, it was possible to fit the extra seat forward

of the steering wheel. Weather protection is seldom extended to the hind seat.

(3) *Tonneau Phaetons, or Tonneaus.*—These were the most important type of body until chassis were lengthened sufficiently to give a proper side entrance. The normal type was curved out in plan so as to accommodate one person in each hind corner, and at the same time provide a gangway leading to a narrow hind entrance. This inconvenience was compromised by various forms of front entrance, in which the near side portion of the front seat hinged, or swung round, or in some cases this seat was done away with entirely. The weather protection consisted of a cape cart or leather hood with a detachable flap if entrance was at the rear, and sometimes a canopy was fitted. A limousine (*q.v.*) top was often fitted so as to afford complete weather protection. The windows had to slide or hinge, as the lower portion of the body was not designed to allow for glass runs. Front entrances were adopted, in earlier types of limousines and landaulettes, while modifications of this principle are in use to-day.

(4) *Side-entrance Phaetons.*—This is the most popular type of body, and constitutes a "standard body" with several motor manufacturers. The first patterns were simply tonneau phaetons with the hind portion pushed further back, and a pair of doors let in. In modern patterns there is a tendency to do away with the distinct bulge at the hind seat, using instead a gentle curve from back to front. The supplanting of the hind-entrance tonneau by the side-entrance one led to the old hind gangway being utilized as a place for an extra seat, from which has arisen the demand for "three on the back seat" in this and other types of bodies, which has done much to retard the progress of motor body design. A side-entrance phaeton usually has seats for two on the driving seat, and for three on the hind seat. Longer bodies have extra seats fixed to the lining boards behind the driving seat, or two single seats may be placed facing forwards, so that the total seating capacity is, in these cases, for seven persons. Doors of equal height are fitted in modern patterns, and a wind shield, together with a double extension cape cart hood, is almost invariably fitted. A *double phaeton* has both seats as near alike as possible. A *triple phaeton* is a side-entrance body in which the central single seats

are built into the main framework of the body, and form an integral part of it. Capt. Masui's "torpedo" body, the styles of "touring" car used in the Prince Henry trials, were amongst the main influences which led to an improved design of side-entrance phaeton, which has no recess at the seat line, but has full panelling like a park victoria. In plan the body is straight or flat-sided, although there is a slight side sweep.

(5) *Protected Phaetons.*—These are side-entrance bodies having a canopy and a hind seat protected by panelling above the elbow, relieved with side or backlights or both. This type may also have an extra set of seats, either facing or with their backs to the driving seat, in which case they may be similarly protected as the main hind seats. "Protected" is a term which may be taken to mean the provision of panelling with or without windows as a weather protection, and is a scheme which is extended to two-seated cars, and the driving seats of limousines, and landaulettes. Half-doors may be utilized in conjunction with this style, but the use of a full door with a light complete makes the body an enclosed car, such as is described below, under (14) and (15).

(6) *Single Broughams.*—These are side-entrance bodies with driving seat and an enclosed hind seat. There are lights in the doors and front of the body, but none in the upper side quarters. A canopy may be fitted to protect the driving seat, and high front doors and windshield will be fitted in most cases. The French term *coupé* is synonymous.

(7) *Double Broughams.*—The addition of a square, D-shaped, or circular front, between the doorway and the driving seat, to a single brougham, constitutes a double or fronted brougham, and is a pattern which has found little favour as a motor carriage.

(8) *Single Landaulettes.*—This is the most popular type of closed motor carriage, and has become familiar to all as a "taxicab." The disposition of the seats is the same as in a single brougham, but the top, or that part which covers the hind seat, is made to fold down, the upper quarters being made of leather fastened to hinged pillars and slats. There are various ways in which the body may be wholly or partly opened.

(9) *Double Landaulettes.*—These differ from single landaulettes in the same way that single broughams differ from double ones.

(10) *Limousine Landaulettes* (Fr. *landaulet limousine*), also called side-light landaulettes, extra side-light landaulettes, and described sometimes as three-quarter landaulettes and double landaulettes. This type differs from the single landaulette in having a side light behind the doorway, instead of in front, as in a double landaulette. The description three-quarter landaulette is the translation from the French term, *landaulet trois-quarts*, for a double landaulette, but as it really means a landaulette with three quarters (the doorway, front seat, and hind seat being each a "quarter," a term not to be confused with a *fourth part*), it is admissible in describing this kind of landaulette, but it is never used by the French people themselves. There are various ways of collapsing the upper structure, and sometimes a square or D-front is added, so that there are three lights each side. The proper term for such a body is a double or square-fronted (as the case may be) limousine landaulette.

(11) *Landaus.*—These bodies have a driving seat, and a closed front and hind seat separated by a doorway. The upper quarters are of leather, constructed to meet over the doorway, and open outwards in opposite directions. Although the front quarter is made as short as possible, so as to keep the body compact, the landau body is not suitable for a chassis where the engine is mounted in front of the dashboard, as a very long wheel base is required, creating disadvantages which quite outweigh any convenience which may be obtained in the body. A double landaulette, or a limousine landaulette, however large the extra light or body may be, cannot be described as a landau, of which the essential feature is not size, but opposing upper quarters, capable of folding. A double landaulette, which has a folding framework to the side and front lights, may be described as a side-light landau if the exterior effect of the lower front panel balance that of the hind one.

(12) *Cabriolets, or Landaulette Phactons.*—These bodies combine the features of a side-entrance phaeton and a landaulette, for which reason the term "landaulette phaeton" is more suitable than "cabriolet," which only refers to a certain shape of body. The ordinary cabriolet is a single landaulette in principle, with more dome to the roof, and rounded corners at the rear. The whole of the superstructure collapses either separate to or in conjunction with

a leather canopy to the driving seat; cabriolets may also have a side light like a limousine landaulette, when they are properly called limousine landaulette phaetons. Cabriolets have been designed in which the driving seat is fully enclosed. The bodies are on the whole somewhat complicated, and are not so economical in wear and tear as a simpler single or limousine landaulette.

(13) *Limousines.*—Small bodies of this type are practically broughams with a side light to the top hind quarter, instead of a plain panel; in fact, such bodies are often called *coupé* limousines. Small limousines are, however, generally longer in the main portion of the body than broughams. Limousines have usually hind round corners, and the seats built into the body are always arranged transversely. Extra seats of various patterns are fitted to face in various directions. The main portion of the body may communicate by means of a door, centrally placed behind the driving seat, so that a "corridor" entrance is provided. Large and luxurious limousines are sometimes called "pullmans" and "saloons," but there is little to recommend the practice. Limousines are sometimes built with a square, or D-front, when they are properly called a double, square, or D-fronted limousine, as the case may be. Windows may be arranged all round the upper part without any relief of panelling. Such a body is often referred to as a "berline."

(14) *Single Enclosed Cars.*—These are bodies in which the driving seat is fully enclosed. The upper portion may be fixed or detachable, and of the brougham, limousine or landaulette type, which variations suggest the subdivisions under which this class of bodies may be placed. It is incorrect to call such a body, for instance, a single landaulette, as the proper body so called has a separate driving seat. "Self-driving" is a good term to use, as these bodies are often designed so that the owner may himself drive, and this description should be added to the term, such as "limousine or landaulette," which is descriptive of the general appearance and type of protection afforded. The single enclosed type may have an extra seat at the rear, which is seldom protected.

(15) *Double Enclosed Cars.* — These are limousines or landaulettes in which the driving seat is fully enclosed. A corridor entrance may provide communication between the driving and

main portion of the body, or the whole seating may be arranged without any division at all, in which case there is usually a single entrance each side only. These bodies may be subdivided under the heads mentioned under No. 14. The term "pullman," "saloon," and so on, is also used indiscriminately in connection with these bodies, as with large limousines.

(16) *Wagonettes.*—The essential feature of a wagonette is that the seats, in the main portion of the body, shall be arranged longitudinally. A hind entrance is usually adopted, although in some shooting brakes side entrances may also be provided. Lonsdale wagonettes have a folding head working in the same way as a landau (see No. 11), and the end view is therefore practically the same as a side view of that type of body, while the side elevation corresponds to the back or front view of a landau. By this means one obtains the advantages of a landau on a short wheel-base.

(17) *Omnibuses.*—A wagonette with a fixed or removed top fitted to it becomes an omnibus. The lights may be made to slide, hinge, or drop according to the design. Wagonettes and omnibuses, having hind entrances, do not find much favour as private vehicles.

(18) *Dog-cart Phaetons.*—Although largely used during the first two or three years of motoring, the Jackson car is about the only modern instance where a body with bent sides, or other characteristics of the countless varieties of two and four-wheeled dog-carts, having both seats facing generally forwards, and not back-to-back, is used.

The above varieties will be found to include all modern cars. The sociable, barouche, four-in-hand coach, canoe landau, Stanhope phaeton, and other horse-drawn carriage types, have been adopted to motor traction in a few instances, but not in sufficient numbers to be worthy of particular mention.

# CHAPTER II

## *THE DIMENSIONS OF THE BODY*

The chief influence on the size of a motor body is the normal dimensions of the adult human frame. The doorway is roughly the width across the hips or shoulders, although, as the body is usually entered at an angle, this measurement may safely be reduced a few inches. The height of a closed body, such as a limousine or landaulette, is consistent with such crouched position as may be maintained with a minimum of inconvenience for a few seconds, while the height of the seat above the floor (including the cushion), its width and depth, is dependent upon the length of leg and size of hips. The overall height should also be sufficient to clear the hat of a lady passenger when seated.

*Head Room.*—This dimension is reckoned either from the top of the floorboards, or the top of the seatboard to under the centre of the crown of the roof. In limousines and landaulettes the height from the floor will average 5 ft. The height of the seat will depend on the thickness of the cushion, and normal measurements are 10 ins. to top of the seatboard in front and 9 ins. at the back, allowing for 6 ins. of cushion. With landaulettes the headroom has also to be designed so that the hoopstick which has the least radius, or is nearest the doorway, shall clear the backrest of the hind seat, otherwise it foreshortens the interior accommodation when the head is open. Similar allowances are made in side-entrance phaetons having cape cart hoods.

*Leg Room.*—This dimension refers to the vertical, as well as the diagonal, position taken up by the lower leg when one is seated in an ordinary manner. Some modern bodies are fitted with low seats which practically admit of lounging. The height of the seat, 16 ins., as given in the previous paragraph, allows for comfortable

leg-room vertically, while from 22 ins. to 24 ins. are required for the diagonal measurement, which is an approximate measurement of the distance between the edge of the driving seat and pedals.

*Knee Room.*—The horizontal measurement allowed for the upper leg forward from the edge of the seat when seated should not be less than 11 ins. In bodies where there are an additional pair of single seats facing forwards, one has often to consider whether to make this allowance of 11 ins. and encroach on the gangway at the door, or else cramp the knees of the passengers on the hind seat. A body has to be of considerable length behind the doorway if a pair of extra seats are to be fitted up comfortably, and the doorway left clear, in fact 48 ins. would not be too much for the length on the seat line behind the door. Knee room in the facing seats of wagonettes is an important item, and the measurement between the seats should not be less than 18 ins., which does not allow for any gangway between the seated passengers. In a public service omnibus the gangway is at least 26 ins. Knee room has also to be considered as between the top of the driving cushion and the under surface of the steering wheel: an average measurement for this clearance is 9 ins.

*Seat Room.*—An average-sized person cannot sit with comfort for any length of time on a seat of less that 16 ins. in width; this, however, does not strictly apply if the seat is isolated. Two persons sitting together on a 32-in. seat would be fairly wedged in, even with a moderate amount of clothing. In many motor bodies the allowance is at least 22 ins. per person, especially when two only are carried, as in a driving or hind seat. It is when three persons are carried that the measurement has to be considerably reduced, and 16 ins. and 17 ins. are often the allowance found in an otherwise luxuriously appointed landaulette. The depth of seat, from back to front, may be anything from 16 to 24 ins., 22 ins. being a normal measurement for a comfortable hind seat, while the chauffeur can usually drive with ease with an allowance of 18 or 19 ins.

*Gangways and Doorways.*—The most important gangways in a body are the entrances at the doors. One can squeeze through a 16-in. opening, if the struggle is made sideways. The normal measurement, however, is 21 ins., which is more essential above

the waist or elbow line than below for the legs. The width of doorways has of late shown a tendency to increase, and measurements greater than 24 ins. are often met with. To increase this measurement means a heavier door, requiring stronger hinges, stronger framework to fasten them to, and a structure consequently more susceptible to binding. Half-doors, such as are used as front or wind doors, need not exceed 19 ins. to 21 ins., as passage-way has only to be allowed for the lower part of the body, but an increase in width of a half-door tends to comfort. Gangways between seats, being inside the body, have to be reduced to a minimum, in order to economize space. From 12 ins. to 14 ins. may be reckoned as an average dimension in this direction.

*The Influence of Chassis Sizes.*—Before the motor body builder can arrange the dimensions of the body he has to consult the blue print provided by the motor manufacturer. In some happy instances he is practically unfettered, in other cases he is seriously hampered, generally because the motorist insists on a style of body which is not consistent with the design of the chassis.

The position of the brake and gear levers, steering wheel, and pedals decides the location of the driving seat. A raked steering column generally means that the measurement, from the dashboard, will be increased from the normal measurement of 24 ins. up to something in the neighbourhood of 30 ins. The distance which the levers stand away from the side of the chassis also influences the shape of the front doors. Possibly in future chassis these levers will be placed centrally, as has already been adopted in some American cars. The height of the driving seat is often dependent on the depth of a petrol tank placed beneath it when the carburettor is gravity fed.

The width of the main doorway used to be greatly influenced by the position of the hind tyre, but now that wheelbases are more generous this does not so often apply, except when a large body is crowded on to a small chassis. A vertical wing clearance of $4\frac{1}{2}$ ins. to 6 ins. having been allowed, the lower part of the door is curved round on the wing side so as to economize space where it is not required. The turnunder of the body also assists the opening door to clear the wing. The position of the wheels also influences the width of the body, and consequent seating capacity,

especially if the seats are placed low. There are few chassis which do not allow of two being seated comfortably at any height inside the body, but there are few which allow of three being easily accommodated on a low cushion. A compromise is usually effected by cutting away a portion of the side framing (paddle-boxing), which gives hard ends to the cushion, or else building the seat over the wheels, which does not always give a proper height from the floor, unless the latter is built up higher than usual, necessitating a heavier and ugly bottom to the body.

The length of the chassis, behind the dashboard, should be the same as that of the body, but often this is ignored, making an unsightly vehicle and one which is liable to skid, and bear unduly on the hind tyres.

A chassis which is curved up at the rear usually means that the straight portion is a couple of inches lower than it would otherwise be, so that the body will be easier to get into. Chassis are also cranked in the centre, so that the body is lowered a further few inches, but the crank is useless unless the particular type of body for which it is designed is mounted upon it.

*Allowances for the Framework.*—Bearing in mind these elementary considerations which govern the size of a body, the designer is able to produce any style desired by allowing, beyond the measurements stated, the thickness and depth of the pillars and other members of the framework.

In a limousine an allowance of 2 ins. has to be made for the front standing pillar before the door space can be apportioned, and we must have the same measure, at least, before allowing for the side light, if we wish to bring it close to the doorway. In reckoning the width of the body, the thickness of the framing has again to be considered, and some 5 ins. or 6 ins. are added to the interior dimensions in order to arrive at the overall measurement.

# CHAPTER III

## *BODY DESIGN (PHAETONS)*

*The Horizontal Lines of the Body.*—The motorist judges the appearance of a motor body chiefly by its exterior effect; the practical man would prefer to pull it to pieces before giving his verdict, as good design relies more on good constructional arrangement than on mere outline. The bottom of the body follows the outline of the chassis, the seat line (which will not be visible in a flush-sided body or where there are plain full panels) is usually a straight line running under the driving seat and continuing sometimes across, but generally broken at the doorway, to the back of the body, while the elbow line, which is from 11 ins. to 18 ins. above the seat line, is designed, when there is an open seat, so that the arm may be rested comfortably at that part of the body, but where the seat is enclosed or the panel is deep an inside elbow may be placed in position independently of any exterior line. It is usual to raise the line at the elbow at the back end, which is only an inch or two in the normal pattern of landaulette with square hind corners, or some 6 ins. to 9 ins. in many side-entrance phaetons, where the elbow line rises in a return curve to meet the top line of the back panel, and to provide comfortable support for the shoulders.

The roof line, which is usually straight from back to front, but curved about $1\frac{1}{2}$ ins. from side to side, is placed some 5 ft. from the floor. Thus we have laid down the main horizontal lines of the body.

*The Vertical Lines.*—Regarding the vertical lines, the dashboard and front of the driving seat is already apportioned out by the design of the chassis, so that we have left the lines of the doorway and the back of the body. If we are dealing with a

closed body, which has a drop light behind the driving seat, the door position will be governed by the back line of this seat, but in an open body with a round-cornered driving seat, the front of the door may be brought 2 ins. or 3 ins. forward, as this will not interfere with entrance at an angle. The back line of the body is generally drawn when the designer has finished apportioning out the doors and seats, and this should coincide with the hind cross member of the chassis. If it comes in front of this so much the better. There are many side-entrance phaetons with a huge space between the back of the driving seat and the front of the hind seat, suggesting that the hind seat has been placed above the end of the chassis without regard to even maximum knee room behind the doorway, the chief desire being to fill the available mounting space with body work. Many hind seats are wholly behind the hind axle, some are placed centrally over it, but it is only in exceptional cases that the seat is all in front—the ideal position.

*Moulding Display.*—The outline of a body is mainly expressed by the mouldings, which are sometimes formed out of the solid of the ash framework, or else as wooden, metal, or cane strips pinned or screwed on. A moulding will follow closely the outline of the driving seat, the framework to which the door is hinged, along the hind seat line, right round the back of the body, and also along the elbow in a similar manner. Such mouldings give a finish to the panelling, and also assist to hide the means whereby the panel itself is fixed to the framework beneath. Apart from such necessary mouldings, others are introduced merely to decorate the body, and unless the scheme is carried out with restraint and good taste, it becomes a most sure guide to the want of ability of the designer, as the " breaking up " of surfaces is often badly done, little regard being given to good freehand outline or balance of design. In a large body an extra moulding or two can be judiciously inserted in order to help the construction; for instance, it would seldom be economical to run one piece of panelling from one door right round the back to the opposite door in a long body, and a vertical moulding in the centre of the back, or one in each hind corner, allows the panelling to be done in three pieces, such lengths being arranged to coincide with the framing of the body. It is generally a sign of bad design when framing or other means of

fixing has to be inserted merely to carry a moulding. A moulding is often run parallel below the elbow of the body or driving seat so as to form a belt panel, which can be coloured in contrast to the lower portion, and is only desirable when the panel surface is deep and requires this method of relief.

The toe of the front standing pillar is an instance where symmetry of outline has been studied rather than actual strength of timber required. The outward sweep of the bottom of the pillar harmonizes with the upward sweep of the elbow line, the back line of the bottom of the hind standing pillar, and is often similar to the vertical curve of the back of the body, and the lines of the driving seat. The toe of the front standing pillar is often exaggerated, and even brought out into an extravagant sweep across the rocker side beneath the driving seat. This is not only inartistic, but is expensive both to construct, paint, and keep in repair.

Not only should the amount of moulding be restrained and used chiefly as a means to express the main lines of economical construction, but it must be carried out by an able freehand draughtsman, if an artistic effect is to be obtained. A curve must not be broken, and where it runs into a straight line, the junction must be easy and natural, therefore imperceptible. Theoretically, the horizontal lines of the body should be parallel with the ground line when the body is loaded, and if there is any slight dip, when the body is mounted on the chassis, it should be towards the front. The vertical lines of the pillar outlines will be at right angles to these lines. Any two portions of a "straight" line should be absolutely in line, and nothing will spoil a body more readily than an elbow line which drops or rises slightly immediately it leaves the doorway.

Most builders construct their bodies square above the elbow line; some firms throw out the body slightly at the top, so that the end view in the latter instance has no tendency to look falling in at the top.

*Panel and Window Areas.*—Apart from the mere outline of the body, we have the surface broken up into panel and window areas. In a limousine the side lights are an important item in the design, and the hind standing pillar has a run formed in it in which the light may slide. On the other side of the light a

pillar is framed in specially to carry the light. The upper part of the door is always given up to a light; generally the whole of the front of the body, and a good portion of the upper back panel is glazed also. The lights of a body, with the exception of the hind light, are usually relieved all round by means of a wasting formed out of the surrounding framework. If the light is fixed there is often a returning fillet, or bead, as in a back light.

Although a window allows light and air to enter the body and relieves the panel surfaces, yet in designing a body it must be borne in mind that plate glass is generally heavier than a corresponding panel surface, and also weaker.

*Turnunder.*—In order to add to the artistic effect and economize material and weight, a body is contracted in width below the elbow, generally by a curved line following the various forms described at the beginning of Chapter I. As the width on the seat is always more than the width of the chassis, some turnunder is necessary, unless the bottom is to overhang the side of the chassis unduly, but it must be admitted that there is not sufficient understanding between the carriage builder and motor manufacturer as to what constitutes minimum width, for many bodies 54 ins. wide are mounted on a 36-in. chassis. If there is a wide seat, in the neighbourhood of the hind wheel, turnunder is essential, in order to clear the tyre, and because a drop light is running in the framework adjacent to the seat, a great thickness of pillar is necessary. Five and 6 ins. turnunder is not unusual in a motor body, but $1\frac{3}{4}$ ins. was considered normal in a horse brougham built by the leading London houses. What is the use of giving a comfortable seat if one's feet have to be kept together owing to want of width on the floor? Many a body is spoilt in this way because motorists will not be content with a normal seating for two on the back seat, say, 44 ins. between the standing pillars, and the motor manufacturers will not increase the width of their chassis beyond 37 ins. Moderate turnunder given to a body enhances the appearance by the amount of reflection given to the panel surfaces when well varnished; maximum turnunder gives a distorted appearance.

*Side Sweep.*—The exterior curved shape of the body in plan is the side sweep. It enriches the appearance and is economical from

a constructional point of view, and has been put to better uses than turnunder. The contraction of a body towards the back is allowable, as one does not require so much room at the back of a seat as at the front. In a landaulette a lesser width is necessary in order that the pillar tops may fall outside the elbow and rest on the body props. The body may be again narrowed at the front, behind the driving seat, because the width is not wanted, although with luxurious folding seats so often fitted to the front lining boards, this does not always apply. If we carry a regular sweep right from back to front, that is from corner pillar to dashboard, the effect is simplified, but, on the other hand, we get more width at the back of the driving seat than is required, and unnecessary width generally means unnecessary weight, unless the disadvantage is compromised by using it to give increased locker space below. In a long body, with extra seats facing forwards, the side sweep must be well under control, as there will be a comparatively long surface in which about the same width must be maintained, therefore the sweep here should be almost flat.

In a well-designed body all absolutely flat surfaces should be eliminated as far as possible, and even the back panel should have the framework dressed off so as to leave a slight fulness (say $\frac{3}{16}$ in.) in the middle.

Given the turnunder and side sweep, the draughtsman is able to work out the width of the body at any part.

*Round Corners.*—The side sweep, in limousines and phaetons, has generally to be associated with a rounded corner to the hind seats, and the front seats, if of the bucket pattern. The corner will be of about 9 ins. radius if we desire to give a comfortable rest for the shoulders right in the corner, while care must be taken with the smaller curve at the seat line in order that the turnunder shall not be marred. Small rounded corners are often used simply to take off an otherwise sharp edge, and lighten the apparent bulkiness of the body. These corners are often got out in the solid, and it can be arranged so that a specially shaped head is not required, if a landaulette top is used. Rounded hind corners to the leather heads of landaulettes, cabriolets, and phaetons, however well they may look when new, soon become shabby in appearance, as the leather cannot be properly stretched.

*Roof Sweep.*—The roof of a closed body is swept from side to side so as to throw off the water. It also is more artistic, and is a stronger structure for carrying luggage. Too much sweep is unsightly, generally produces a drumming noise inside the body, and if luggage is carried, throws it on the luggage rail at the side. A roof swept from back to front is sometimes seen, and the less height at back and front is not objectionable, as these are positions in which the full headroom is not required.

*Recessing.*—By fixing the rocker sides on to the inside of the framing at the seat line, a recess is formed. This helps the designer to narrow the body on the bottom so as to bring it nearer to the width of the chassis. As indicated with turnunder, this generally means that the feet are cramped when the seats are fully occupied, and one sometimes sees a rocker side specially built out to give more foot room just where it is wanted. The flush-sided body tends to do away with this grievance. A recess, although it relieves the monotony of one level of panel surface, is considered a dust-raising factor on the usual macadamized road. Recess is at its best when the thickness of one panel is allowed to overlap an adjacent one as the top quarter of a brougham, or the manner in which the panels themselves are recessed from the mouldings. A recess of a quarter of an inch can hardly be considered a serious dust raiser, but when it is increased to 6 ins. and 7 ins., as at the standing pillars of a large limousine landaulette, it can be readily understood that here is a chance for temporary vacuums to be created, as the car rushes along.

## Various Points in the Design of Leading Body Types

*Two-seated Cars.*—Having ample wheelbase with relation to the position of the seats, it can generally be arranged that a 22-in. seat is allowed for, which is well in front of the hind axle. When the tank is on the dashboard, the motor body builder is left entirely free as to locker space, while a tank slung behind the driving seat is an eyesore, although this may be compromised by putting it between the squabbing and the back panel. When there is some 28 ins. from the dashboard to the front of the driving seat, there

is ample room for the forward tank position, which is not only accessible and readable as to quantity contained, but it means less piping and greater efficiency at the carburettor. The hind locker space may take upon itself many shapes; the best plan is a gentle slope towards the rear for the top of it, the end either slightly curved or straight, in which case it must be slightly out of the perpendicular on either side of the vertical line. The sides of the back portion may be a continuation of the rocker sides beneath the seat, or, if a full-panelled body, they will be fixed to the inside of the framing. The sides may also be swept back to a point and small corner platforms made. This reduces dust raising, but the

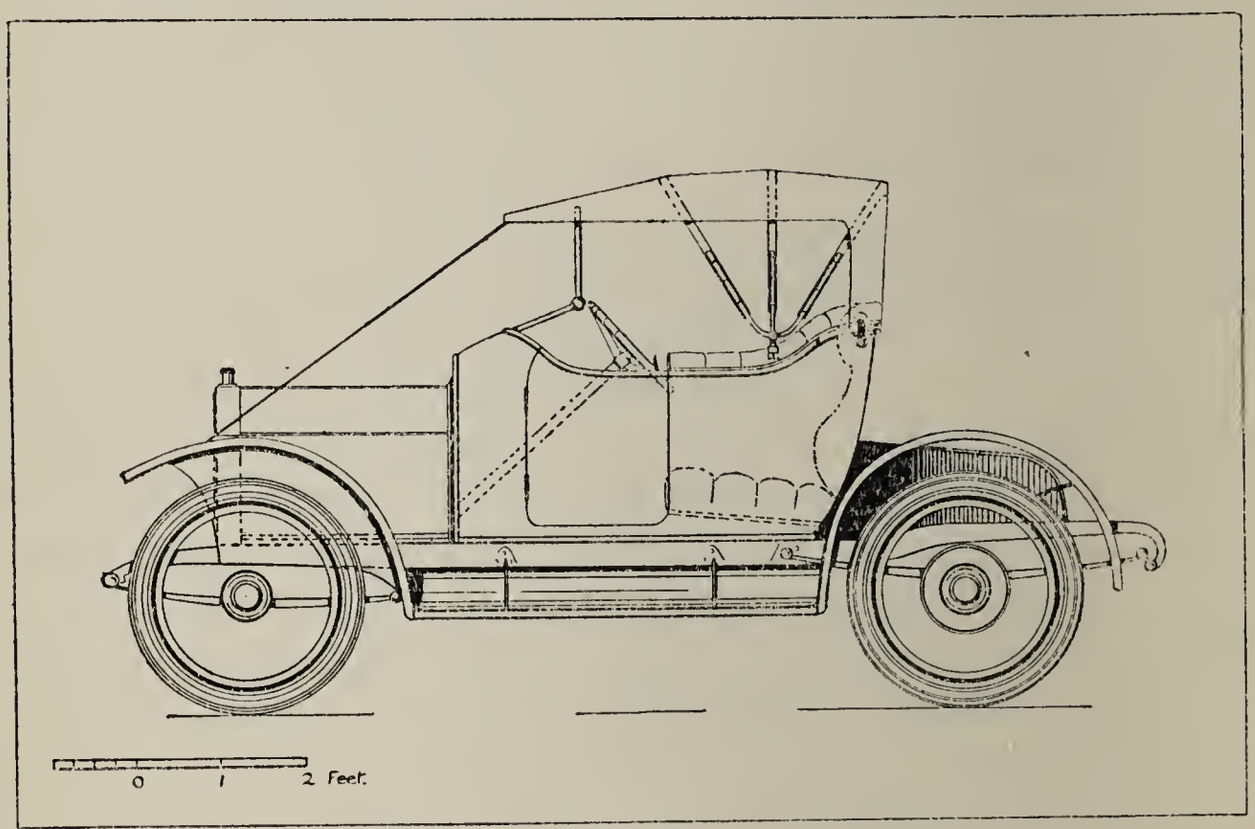


FIG. 3.—Two-seated or Single Phaeton, with tool box at rear.

body is not so useful. All types of bodies should slightly overhang the chassis not less than $\frac{1}{4}$ in., so that the edge of the chassis is hid.

The lid to the large hind locker should open from the top, and be hinged from the front if a single lid. The locker itself can often be usefully divided so that tools do not stray about and rattle. The objection to using separate bucket seats is that a recess is formed at the back which is difficult to keep clean. A single seat with a division is the best practice. Long side steps are hardly necessary unless one is used in order to contain a circular recess for the carrying of a spare wheel, or a battery box. With the use of proper

doors to the front seat, a different type of finish to the dashboard has sprung up, which is rounded similar to the pattern first used some years ago by the Daimler Co., so that a neat corner is made in front each side of the body, and this structure is generally framed to the usual straight dashboard. This scuttle dash, as it is termed, may also be extended back towards the driving seat, and if this is carried beyond a certain point it impedes the gangway and has to be made to hinge with the door. The hingeing may be by hand, or automatic with the opening of the door.

When the top of the back portion is used for carrying luggage, it is a good plan to fit a low luggage rail furnished with strap staples, while the top itself has a few neat transverse battens screwed to it, which is a better method than covering with sheet rubber. The luggage rail should be rigid and not to fold down when not in use. The hood fitted to a two-seater may be of leather, or a light cape cart hood covered with waterproof twill. The enamelled leather hood, although it costs double that of the other material, gives the car a more dignified appearance, and wears considerably better than a cape hood, a matter which should be borne in mind by the professional man who uses a two-seated car. A car which has a panelled or protected top furnished with lights, especially if the side ones are made to drop, is a design which will appeal to many, as the car will always look smart, and there is an absence of complicated parts, which may rattle when worn. The hood, whatever it be made of, should lie as flat as possible when down, so that the car may be driven backwards with comparative ease, it also gives the car a neater appearance, but the use of the hood as a dust screen is lessened, and one must choose between these uses of the folded hood. The design of hoods for both large and small cars is dealt with in the chapter on weather protection. In deciding the width of the front seat, the centre of the steering wheel and column should be the centre of the chauffeur's seat, so that he is comfortably seated with both arms properly supported at each side, and sitting squarely to his work. Those who delight in wide seats must use the extra portion on the driving side as a small glove locker. We occasionally find three on the front seat, but unless the steering has been specially adapted, it must lead to uncomfortable driving with little room for the legs and feet.

*Racing Types of Two-seaters.*—Although road racing is dying out, there are motorists of moderate means who delight in chassis with small engines under long bonnets, and an exaggerated raked steering column. The very low driving seat of minimum wind resistance which is usually provided does away with any useful locker space beneath it, and means a long and therefore rather cumbersome side and dashboard protection, while it is very questionable whether the recumbent driving position is really comfortable, however thickly the base of the back squab may be trimmed, or lends itself to enjoying the view around. Another freak-type of two-seated car is that consisting of a chassis of some 60 h.p., and long and strong enough to carry a seven-seated limousine. The mounting of a two-seated body on such a chassis means that the weight of the body and load is not sufficient to deflect the springs properly, especially the hind ones, so that the body bounces when it is driven rapidly, although shock absorbers may minimize this evil.

*The Commercial Traveller's Two-seater.* — The commercial traveller often finds a two-seated car of great utility, in which case the front seats will be the same as for private use, only the box portion at the rear should be built up higher, almost to the level of the top of the seats, so as to carry a good collection of samples. There is no objection to this high box portion being removable and a lower one used when the car is not being used for business purposes. An ordinary two-seater is made more serviceable for station work if the hind locker is removable, and a flat platform built on top of the chassis, as this is safer and better adapted for carrying one or two heavy trunks than the sloping lid of a tool box.

In designing a two-seated body, it is well to remember that the small-powered chassis will only be sprung to carry a limited amount of body work, so that normal dimensions and locker capacity either in or apart from the body will ensure comfortable riding. A neat tool pocket may easily be fitted up in the leather trimming of the door, a device which will often do away with the necessity for a big box and the long step which carries it.

There are between forty and fifty chassis models to choose from, all of which are suitable for mounting a two-seated body, and the patriotically inclined will find about 40 per cent. of these of British manufacture. The small car has risen to popularity since the 1906

Olympia show, and, if properly treated, provides the less wealthy motorist with a car as speedy and as efficient in hill climbing capacities, if not overloaded, as a large 60 h.p. seven-seated car, with the advantage of a much less cost of upkeep.

The appearance of a two-seater is occasionally spoilt by the use of large car lamps. Very often the cycle type will be found in keeping, and no accessory used should be so large as to be unduly prominent, and as all the panel surfaces are small, moulding display should be particularly restricted.

*Three-seated Cars.*—The extra seat, at the rear, may fold in many ways. A simple expedient is for the hip irons to fold on to the strapped cushion followed by the back rest, when the whole hinges from the front edge of the seat, so that the undersurface of the seat becomes part of the top of the locker. The whole seat may

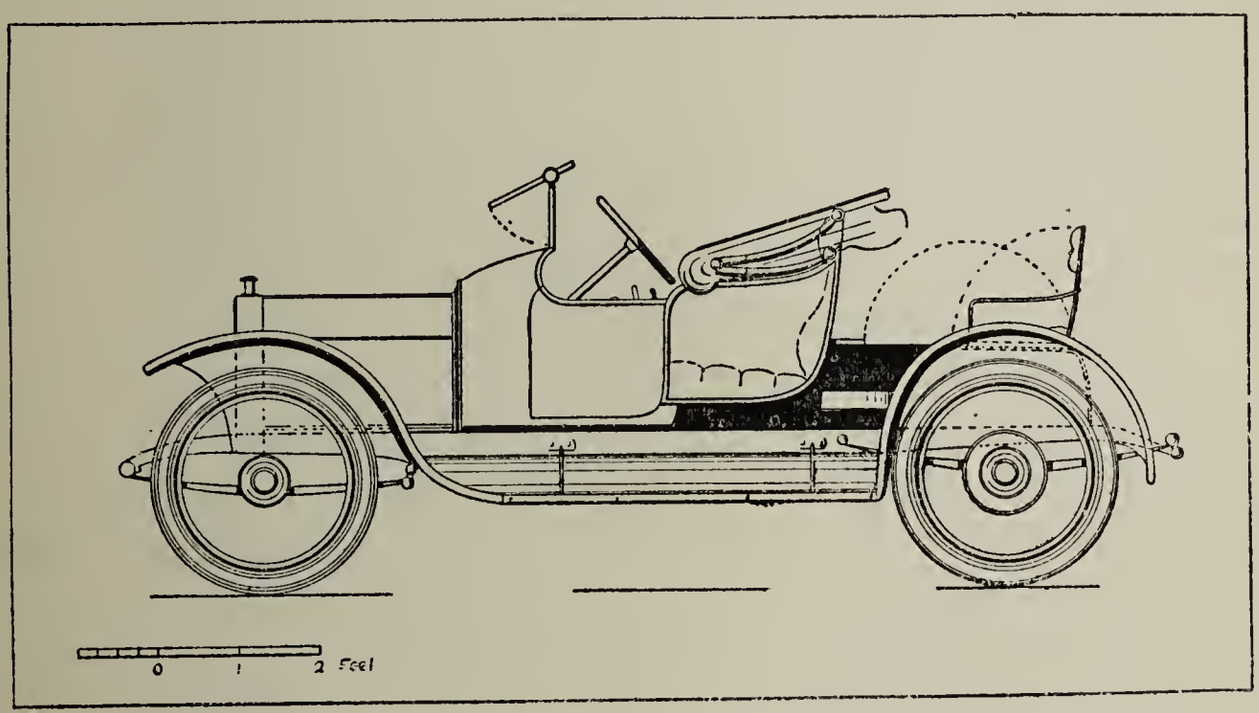


FIG. 4.—Three-seated Car. The dotted lines show the folding of the hind seat and travel of windscreen.

also hinge forward bodily on the lazy-tongs principle. Such seats do not protect the occupant from dust. If a panelled seat be used, it will have to hinge inwards bodily, although a portion, such as the back rest, can be made detachable or to fold. A hind panelled seat requires at least its own depth in the interior of the hind part of the body, for its disposal, and it is also heavier, especially if the sides and backs are trimmed. The simpler the folding mechanism the less liable it is to get out of order and rattle.

Where room allows, the fixed type with panels is the best. A type of body which has yet to find favour is a three-seater which has a side sweep narrowing sharply towards the rear like the stem of a boat.

The position of the rear seat will be as near the driving seat as possible, but allowance has to be made for knee room, the fall of the head of the driving seat, and also the travel of the seat itself if of the folding type.

*Compactness of the Hind Seat.*—Instead of the side of the seat folding inside the body, it may form, when folded, a portion of the side of the body itself, but this method does not give so much protection to the feet. As the third seat is considered an emergency one only, its first consideration is not always comfort. It should, however, not be placed too far behind the hind axle, and it is better to reduce the seating and knee room to a minimum and also mount the head so that it falls as short as possible when down, and bring the seat as far forward as the design allows. When the body is narrowed at the back, entrance *between* the wheel and body can be effected, otherwise the seat will have to be gained by mounting the wheel, or round it either from the back or front, whichever is the more convenient, according to the relative position of the several parts.

Compactness of the hind seating arrangement is also studied with regard to the height of the seat. By keeping the seat as low as possible, the hind boot is kept within reasonable limits, and an increase of comfort can easily be obtained by increasing the thickness of the movable cushion. It is not advisable to make the seat wide enough to carry two persons, even if the allowance is only for children, as the temptation naturally follows to overload the car.

An ideal third seat for a small car should follow closely on the lines of the rumble to a lady's driving phaeton, where it is often admirably incorporated in the general design of the vehicle, and does not obtrude on the notice, or appear to be anything in the nature of an afterthought.

*Tonneau Phaetons.*—The old-fashioned hind-entrance tonneau has practically gone out of fashion. There is no reason why those who are willing to put up with the small inconvenience of a hind entrance should not adopt them where an extra passenger or two is carried occasionally, so that the tonneau would be fulfilling the duties of a

two-seater with extra seat behind. The advantage to be gained in this old type of body is that the extra passengers would be well protected and comfortably seated. The seats could be arranged so that if one person was riding only he could be seated centrally. Then again the general design could be modernized on the lines of a flush-sided phaeton and built low on the wheels, while less swell could be made in the design of the plan so as to seat two comfortably across the back, rather than three. The unoccupied tonneau would

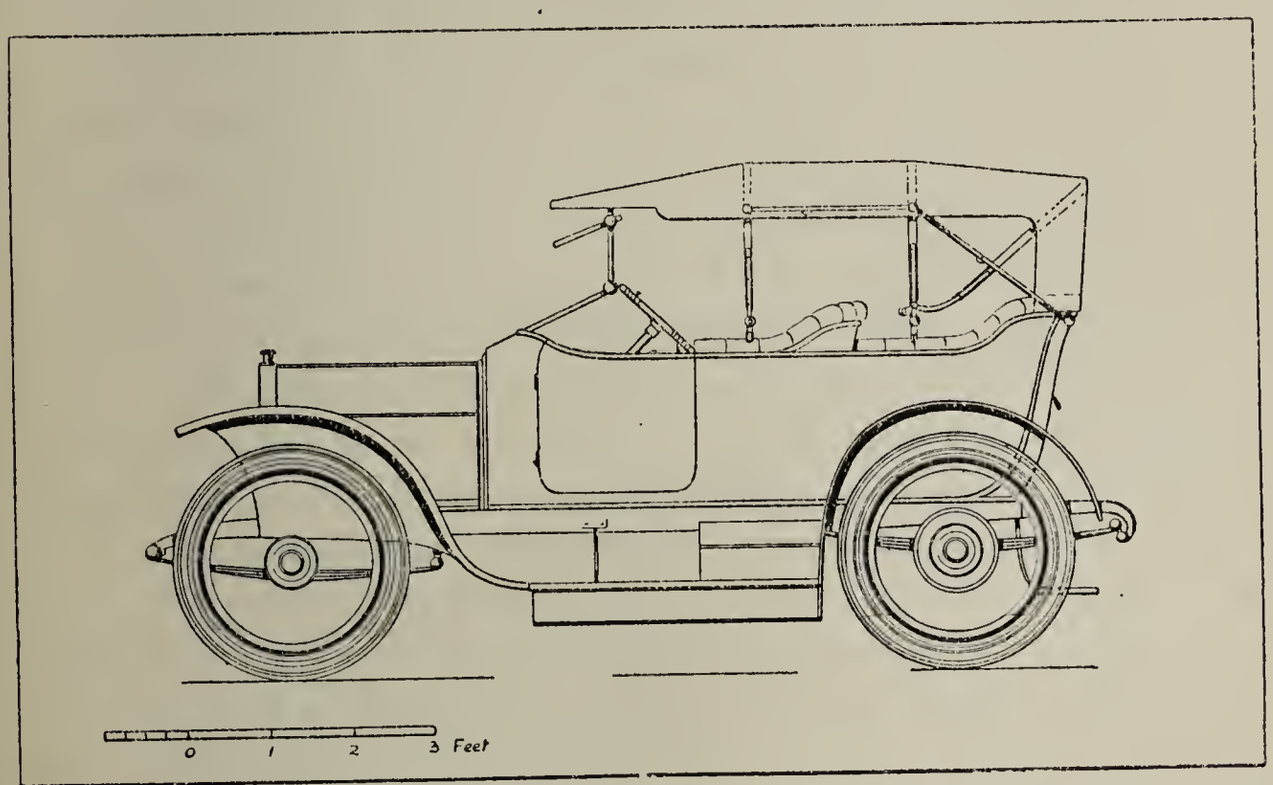


FIG. 5.—Tonneau Phaeton. This has been re-designed on modern lines with flush panels, front doors, and a compact double extension hood. There is a central hind door as well.

also make an excellent receptacle for light parcels, while the hind springs would be made strong enough to carry two persons, or a reasonable amount of luggage. The door, with its flap seat, should be made at least 21 ins. wide. For a body of this description, see Fig. 5.

*Side-entrance Phaetons.*—The use to which the hind portion of the body is to be put is the most important factor in influencing the setting out of the body. Two folding seats on the front lining boards will make a more compact body than extra seats facing forwards. A motorist should be quite sure that he will *generally* be carrying seven persons in his car before deciding, because if five is to be even more than the average load, it is a great pity to spoil

the whole appearance and wearing capacity simply for the sake of a couple of passengers, who may be carried on some rare occasions. Even if four, rather than five, will be the maximum number, he can have a vastly improved type of body if he has courage enough to insist on a four-seated car, rather than blindly follow fashion, and fill the car with seats to its undoing.

*Flush-sided Phaetons.*—The most popular type of side-entrance phaeton to-day is the flush-sided phaeton usually called a "torpedo," which is, strictly speaking, confined to the bodies bearing the licence plate of Captain Masui, a variety of body in which the panels are carried down from elbow to chassis without the usual recess at the seat line. The body in plan may usually be described as "straight-sided," that is, the sides of the body do not swell out merely to embrace the extra width required by the extra passenger in the hind seat. These phaetons, however, often accommodate three on the back seat, so that the body has to be gradually increased in width from the back of the driving seat, unless both levers are to be enclosed in the front. This type of body gained popularity when Captain Masui registered his design in 1908, and the pattern built by the Austin Company, called the "vitesse." The latter had a single entrance only, a mode of entry which was adopted by Mulliner of Northampton at the 1909 Olympia show, only on a different principle, the near side seat of the Austin car hingeing sideways towards the chauffeur's seat, while in the Mulliner body a piece of the side of the seat was attached to the door on each side.

Messrs. Rheims and Auscher (Rothschild) of Paris claimed to have originated the flush-sided body in 1899, when they built M. Jenatzy his "Jamais Contente" car; a reader of the *Autocar* had a similar body built for him in 1902; which facts came to light when various gentlemen each claimed to be the true originators. The idea of a flush-sided body was by no means novel, even before the days of motor-cars, for there were plenty of full-panelled coaches and chariots one hundred years ago, but the particular modification which is usually referred to as a "torpedo" body has only been before the motoring public since 1908. This type of body has received all along the greatest amount of attention in Great Britain, and it is growing in favour in both France and America, although in the latter country designers have seen fit to scoff at it in print,

but have built them readily enough in actual practice, calling them "gunboats," and painting them a "battleship" grey.

Captain Masui's original torpedo body had simple and neat lines, and an absence of unnecessary corners and angles. The elbow line was flat on top of the doors and the seats low and well raked. Part of the design consisted of the scuttle dash, which decreased the area of glass necessary in the wind screen, besides protecting the occupants of the front seat a great deal and the turnunder was of a rotund type.

These bodies are now made by nearly every motor body builder, *Roi des Belges* turnunders are often seen, and belt panels have been used in the scheme of decoration, while many have detracted from the principle of this simple design by using an elaborate display of mouldings. There are some designers who seem to be irritated by a large unbroken surface of panelling, and are for ever eager to "break it up" with mouldings running in various directions. A moulding should not be looked upon as essentially a decorative device, but, as already pointed out, rather as a means to hide the fastening of a panel, or to finish off the edge of a surface. The light and shade provided by the turnunder and side sweep, the difference in texture of the panel and trimming surfaces, are quite sufficient to give a continual pleasing effect, which object is never achieved by mere elaboration.

A flush-sided body should average about 26 ins. in height at the doors, having regard also to the height of the bonnet, and the hind seat should accommodate two persons and be the same width and comfort as the front seat, that is provided with a central arm rest. This is a plan of seating which should apply in the majority of side-entrance phaetons. As the hind corners of the chassis are generally square, in designing the hind panels it has to be decided whether the body shall be made either longer or wider, so that this corner is covered, or else design it according to actual requirements, and in keeping with the general setting out of the body, and leave a naked corner on the chassis to be boarded over. The Arrol-Johnston chassis is made specially to surmount this difficulty, being inswept at the rear. A chassis which is parallel in plan, but rises in elevation at the rear, means that the turnunder must again be adapted to the chassis, while canting in of the side members by the

dashboard will require heavy framing, if the body is to be kept the full width here in order that it shall be properly supported on the inside.

The scuttle dash will take up some 6 ins. or 7 ins. of the front gangway, so that the measurement from dashboard to front seat is often 30 ins., while raked steering is provided so that low seats may be used to help the scheme of a body and passengers offering the minimum of wind resistance.

The panels used are often of steel or aluminium throughout, although wood can be used quite as well, if not to advantage, in comparatively flat places such as the door panels.

The back of the body may be treated in various ways. If the motorist is an enthusiast on the subject of dust raising, he can have the back cut away under the seat and rounded over so that the indrawn currents of air may easily escape, or the rounded portion may be extended backwards so as to provide a locker opening from the rear. Those who dislike the appearance of the spare tyre or wheel attached to the body can have the lower framing made wide enough so that it is carried on the floor at the rear of the body, a position in which it is much better protected.

The hind portion may be made detachable, the point of juncture being an ideal place for a moulding. If the body is running with its front pair of seats only, it is a good plan to ballast the hind portion, or if possible, shift the spare wheel, or other heavy accessory.

The scuttle dash, if well designed, will dispense with the use of rugs except in stormy, wet weather, and this useful device has been adopted for the hind seat protection as well. Of course it has to be hinged, and acts admirably when the hind seats are kept well forward. This type of dashboard is liable to decrease the accessibility of the dashboard fittings, but this is a matter which can easily be rectified by specially mounting the fittings well forward, and chassis differ greatly as to the amount of fittings placed here.

*Semi-Flush-sided Phaetons.*—Several phaetons have the flush-sided panels to the front seats and doors only. An original type of body on these line was the "Torunda," by Messrs. Hewer, and some limousines and landaulettes have been built in this way. This method of design allows a wide hind seat to be used with comfort,

as thereby wheel clearance may be more easily allowed for. Another type of "semi-torpedo" has a low seat line throughout, being practically a flush-sided phaeton with its low seats, but with a very small recess under them.

The two varieties just described may be looked upon as quite modern types. There are also a large number of earlier phaetons —designs which have been evolved since the day of the lengthened chassis—which may be divided into five groups according to whether the body has a straight, rotund, tulip, or *Roi des Belges* turnunder, while the horse-drawn victoria phaeton has also been adapted as a motor body with various modifications.

*Straight-backed Phaetons.*—This is a very simple method of designing the panelling, and the metal panels can be fitted without beating, making a big difference in the cost. The door panels are generally finished with a slight rotund turnunder, the portion above the seat line following the turnunder of the seat panels. If a moderate inclination is given to the back panels, the design looks well, and certainly is to be preferred to a badly shaped body in which an endeavour has been made to introduce elaborate sweeps.

*Rotund Phaetons.*—This variety of turnunder, when carried out with moderation, makes the best style of phaeton, as the curve of turnunder and side sweep can easily be made to harmonize, and the shape of panels is easily trimmed to form a very comfortable back rest. With all types of phaetons, if the hind part of the body is made to accommodate more than one set of seats, the side panels must be made deeper than those of the driving seat in order that they shall look proportionate. Two inches extra depth will be found quite sufficient in order to secure this end even in long cars.

The rotund turnunder also harmonizes well with the exterior outline, such as the lines on the elbow and round the door, and being a common practice with horse-carriage design, there is a wealth of precedent from which to draw.

This type of body is a popular one to-day. The four doors should be the same height, and the practice of adding a roll to each door rail is not to be recommended, because it tempts passengers to lean on the door, which is sometimes a source of danger when it is

closed and also strains the door when it is open. The body, just behind the driving seat, in all types of side-entrance phaetons, is about the same width as the driving seat, whether two flap seats are fixed to the front lining boards or not. With a rounded corner to the front seat, the front standing pillar of the door has to be neatly fitted to it. Seldom is the body wide enough to need any contracting panel, as will be found in a horse-drawn brougham. If a small block or filling-up piece is used between the seat panel and standing pillar, this is best fitted so that it lines with the front face of the

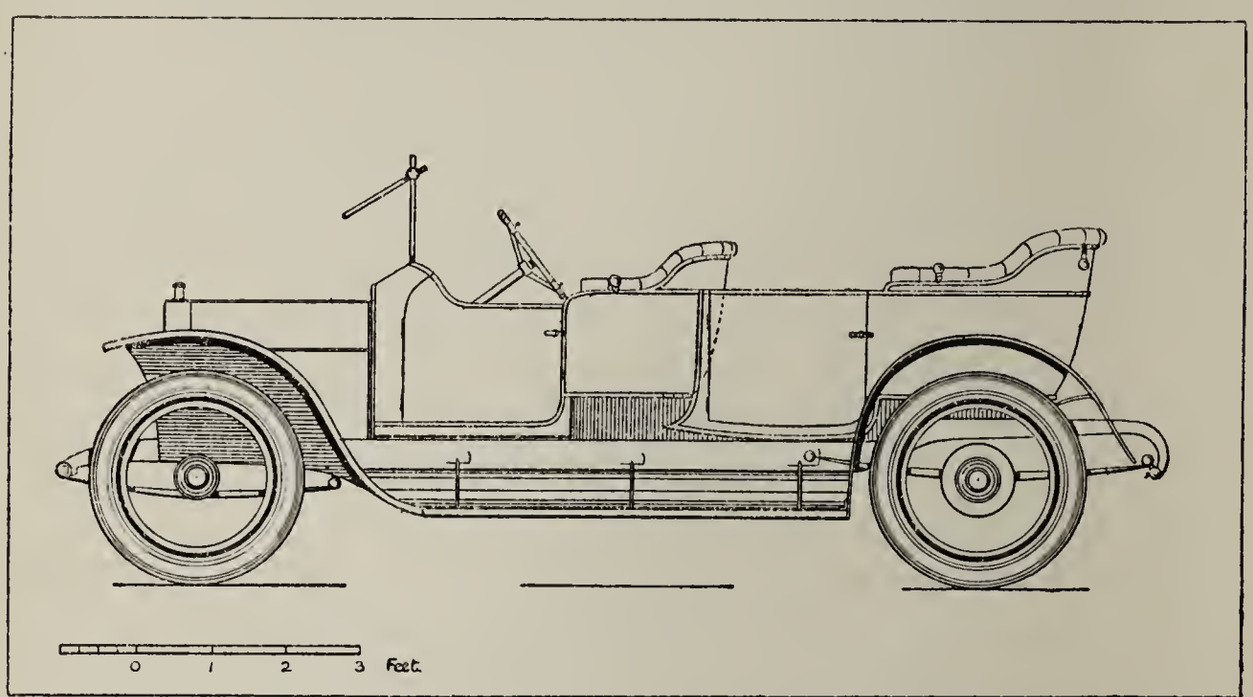


FIG. 6.—Side-entrance Rotund Phaeton. Body props in position for receiving cape cart hood.

pillar. If it forms a continuation of the side face of the pillar, the joint, should it show through the paint after a time, will be more noticeable than if the first method had been adopted.

The rotund type of turnunder lines well with the back of the hood. Carving such as dub ends is falling into disuse on all types of bodies.

*The Victoria Phaetons.*—The adaptation of the horsed park victoria as a motor body took place in the very earliest types of motor bodies, and many of the double phaetons with doors to the hind seats only were to be continually seen. Recent patterns differ from these in that there are proper doors to both seats, and the horsed victoria is also closely imitated when the driving seat is of a pattern with a recess at the seat line. The Shrewsbury phaeton

was an early type with a well-balanced outline, but owing to the wheel base of the chassis at that time, it had a swing front entrance.

The victoria phaeton may be regarded as a flush-sided body, but it is not usually straight-sided. Some modern flush-sided bodies are hardly distinguishable from victoria phaetons, the difference, if any, being that there is no recess behind the driving seat. The victoria phaeton lends itself to many modifications, and several pleasing designs have been evolved. Sometimes a separate hood is fitted to each seat, more often a single leather hood is fitted to the hind seat, with or without an extension piece to a glass screen behind the

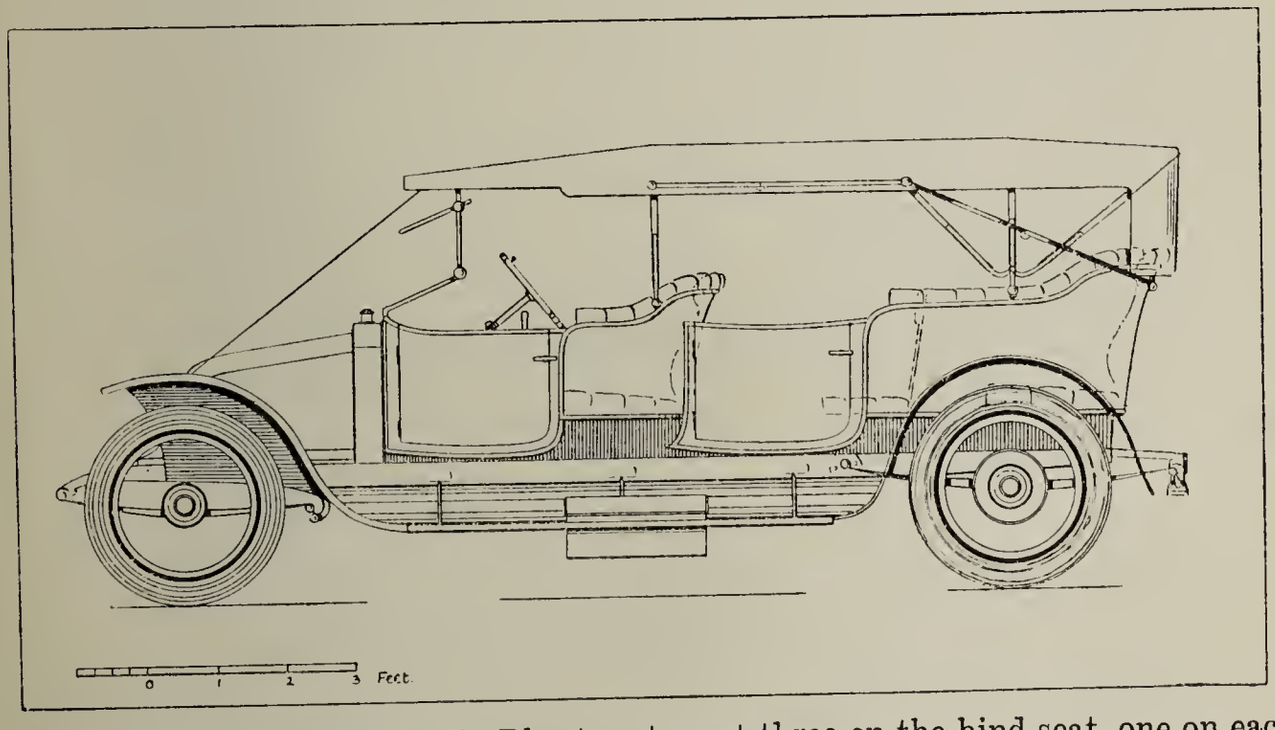


FIG. 7.—Side-entrance Tulip Phaeton, to seat three on the hind seat, one on each of the two single seats facing forwards, and two on the driving seat. An unusually large car.

driving seat, or as far forward as the driving wind shield, but this latter device is somewhat unsightly.

*Tulip Phaetons.*—It is generally understood that the original type of phaeton built for the late King of the Belgians had a turn-under consisting of a straight line with a curve at the top, although the term *Roi des Belges* is now associated with a different shape, as is described below.

The tulip curve, although it can be traced to the outline of the flower of that name, does not at once suggest that connection. It is the simplest curve which can be produced with a minimum of panel beating, but it makes a bad line with the hood when up. It

does not make any great headway in the motorist's favour at the present time, but there is no doubt a field for modified treatment of this outline.

*Roi des Belges Phaetons.*—This has a double sweep to the turn-under, and, as it finishes the same on the top as the tulip curve, it again forms a bad line with the hood when up. When the curve is not too pronounced, the design makes a luxurious-looking body. Some five or six years ago, the *Roi des Belges* phaeton was very

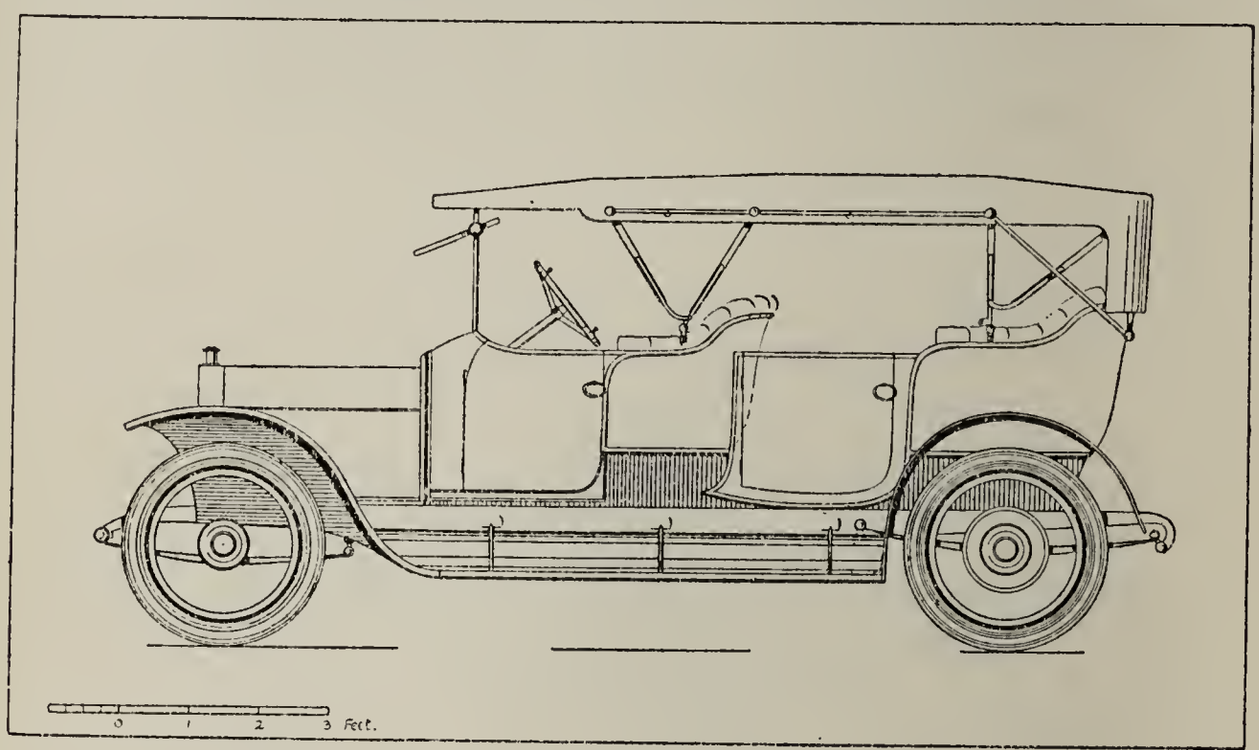


FIG. 8.—Side-entrance *Roi des Belges* Phaeton.

popular, but owing to its adoption as a standard touring car, its use has fallen off as a car body made to order, and using the same argument, some have foretold the disuse of the single landaulette as a private car, because of the adoption of this design as a hackney carriage.

*Protected Phaetons.*—Although many dislike the enclosed nature of the limousine, and at the same time do not care for the openness of the usual side-entrance phaeton, strange to say, the go-between, namely, the protected phaeton, or demi-limousine, is not so popular as it was some four or five years ago. Both the late King and George V. when Prince of Wales had a large body of this type.

The body is seldom made to carry four or five persons only, there being generally a pair of extra single seats. The disadvantages accruing to this type consist in the difficulty of protecting the

remaining portion of the body during inclement weather. The portion from hind-seat protection to doorway can be provided with a window to swing up into the roof, or a curtain which either rolls up or pulls aside. Curtains, however well designed, are seldom properly cared for, and soon look shabby, while the hinged light is generally a source of rattling ere long. The space above the doorway, again, needs similar protection. Some limousines are

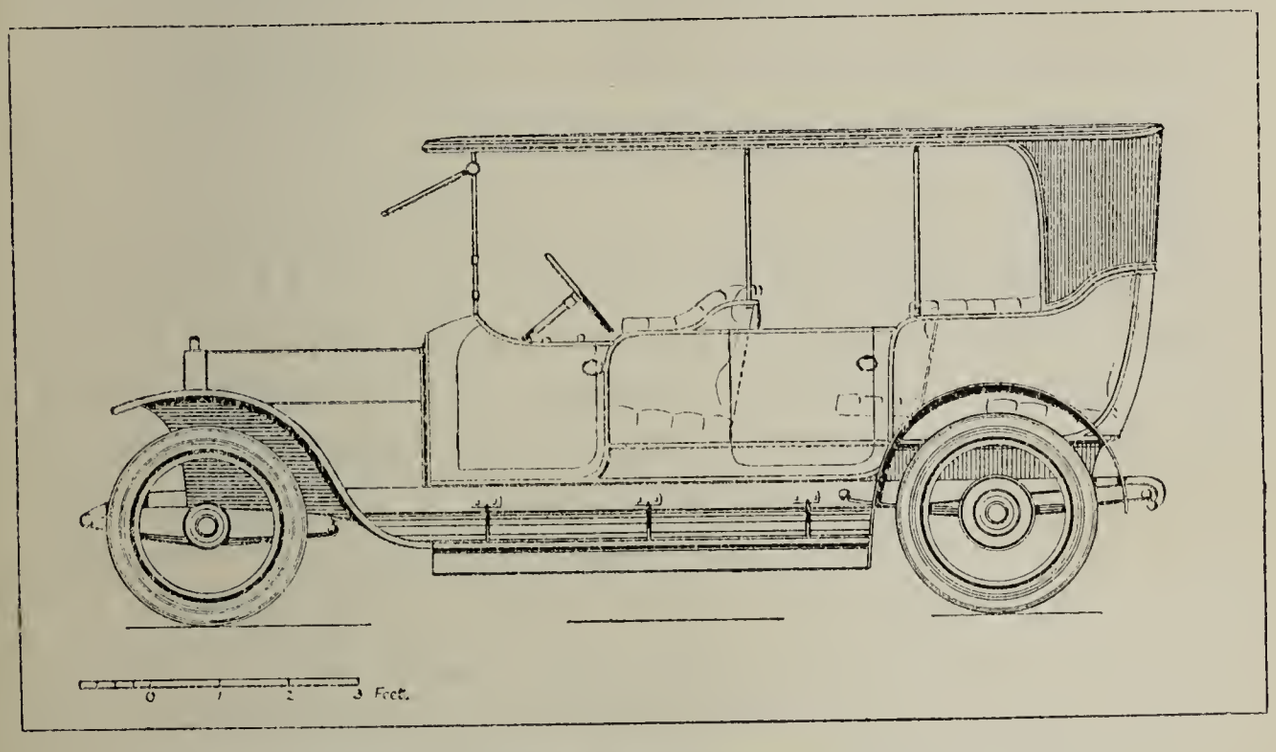


Fig. 9.—Protected Phaeton with seating arrangement, as Fig. 7.

designed in which the hind standing pillar top hinges into the roof, while the side and door lights drop into the usual casings. Such a design of body forms an ideal all-weather car. The protected phaeton type of body will also wear more satisfactorily if the upper hind portion is constructed on ordinary limousine lines. If any pronounced tonneau shape has to be built upon and fitted to in connection with a sharply curved elbow, the resulting contour means a fancy shaped piece of bent glass work, which is naturally weak, and a source of delay to replace. Although a large roof space is provided, it should not have a luggage rail running to the full extent, as the roof is not supported at so many points and as strongly as in a limousine, or other closed-type of body.

The many-seated protected phaeton resolves itself into a char-à-banc, an instance where body types overlap in design.

# CHAPTER IV

## *BODY DESIGN (LIMOUSINES, LAUDAULETTES, AND OTHER TYPES)*

*Single Broughams.*—Considering the tens of thousands of horse-drawn broughams, which have been constantly used for many years by their owners with little expense in the matter of structural repairs, it must naturally follow that this economical design of body fulfils many small requirements incidental to shopping and visiting in town. The single brougham is the simplest type of closed carriage. It has a plain upper quarter panel, there are no folding parts to work loose, it can be built lightly, because all the framing can be set out with little or no waste, and the absence of the mounting of a fore or hind carriage does away with any need for extra strong framing beneath the seats, and the presence of a chassis does away with a costly edge-plate. With the door lights and front lights lowered to their full extent, presenting as they often do nearly 12 sq. ft. of space open to the air, the single brougham has nevertheless been considered stuffy and has by no means become popular, except in a few instances as an electric carriage, and in rarer cases mounted on the usual petrol chassis.

The brougham body may be built with a square or rounded outline, or a combination of these styles. For those who desire extra comfort in riding, the body (minus the driving seat) can be slung on C springs. The designer has no difficulty in producing a good style of body, as there are many good horse-drawn models running about daily. It will be found that the side sweep seldom exceeds 6 ins., and the turnunder of a genuine "Barker" is about $1\frac{3}{4}$ ins. If the body is made 3 ft. 8 ins. on the hind seat between the standing pillars, with a 24-in. door and a 26-in. quarter, a roomy brougham for two will result, which, if painted dark colours,

will make a dignified gentleman's carriage for town work. It is a type that can easily be kept neat and clean with a little care. The finish is enhanced if the usual long side steps are substituted by neat black step treads. Although the provision of a light folding head is permissible, as with the driving seat of a taxicab, yet it spoils the style of the body if it is added to a brougham, and a canopy should be used instead, but often it can be dispensed with, unless the car is to be used for station work.

*Double Broughams.*—The same considerations apply as with a single brougham, but the higher-powered chassis required for this larger body means that the owner must be a wealthy man to keep a large car like this for town work. The brougham is essentially a town carriage, and naturally the man who buys a large chassis wishes to get the utmost use out of it. Therefore the limousine, with its extra means of ventilation and lighting, or the large touring car, often does the double duty of a town and touring carriage.

*Single Landaulettes.*—The construction of a landaulette, of any type, requires more care and skill than any phaeton or limousine body. The folding upper structure demands the exact fitting of several pieces of special ironwork, while the framing must be particularly well seasoned, so that the various pillars and tops, rails and slats will be always the same shape and size, therefore meeting properly every time the head is closed.

The problems surrounding the single landaulette will be readily appreciated if the several kinds of head openings are described. The head may open :—

(*a*) By cutting the hind standing pillar top above the fence, and the cant rail above the front pillar, the whole being hinged so as to fall towards the rear. This type of opening necessitates "half" doors, that is, although there is a drop light, the upper parts of what would be the door pillars in a brougham are incorporated with the standing pillars, although in some instances the extra portion of upper door framework is made to hinge over and backwards on to the door trimming. The pillar top is hinged to the elbow of the body by a pillar hinge, which also carries metal fingers to which the slats which support the head leather and lining are hinged. To the top of these slats are notched the hoopsticks, and

similar but stouter hoopsticks are framed into the cant rail above the door. The hoopstick which is above the top of the hind standing pillar will generally strike the shortest radius from the pillar hinge, and care has to be taken to design the landaulette with sufficient head room so that it does not strike the back of the hind seat when it is thrown down. When long quarters are required the head room is not increased beyond the usual 5 ft. from the floor, but the extra length of quarter required can be allowed for by altering the position of the pillar hinge centre, while sometimes this hoopstick is mounted on a device which causes it to travel a little farther in the required direction.

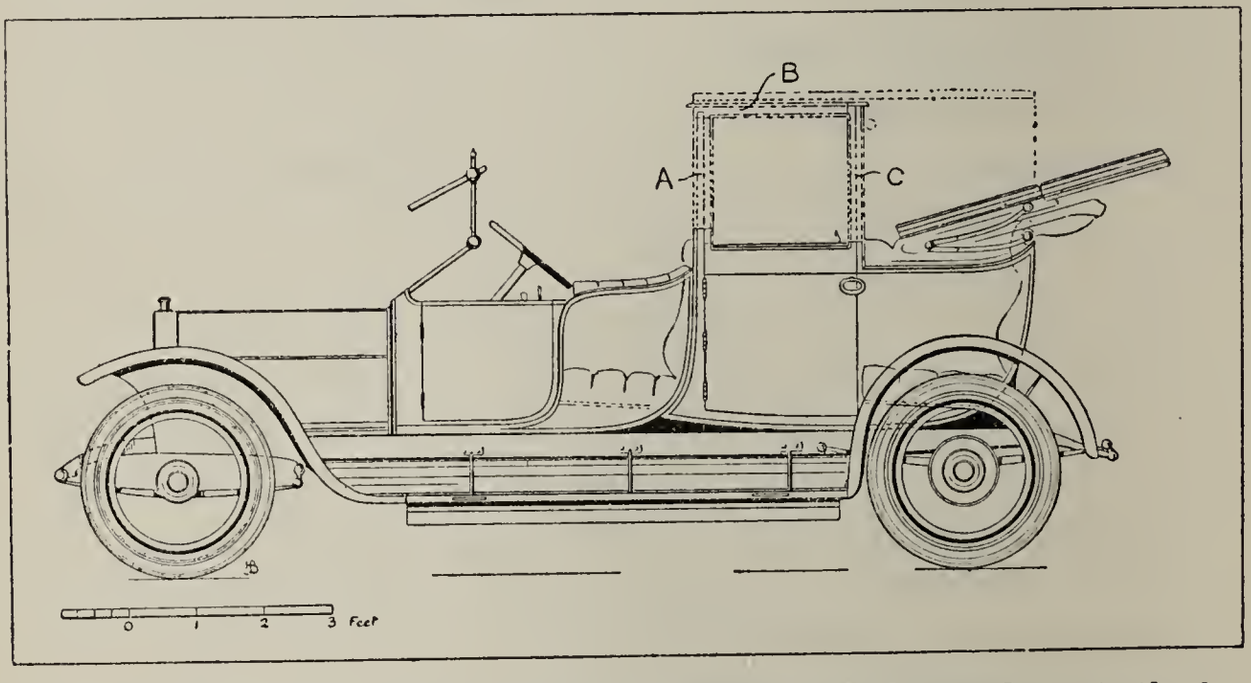


FIG. 10.—Single Landaulette. The front pillars, A, fold inwards on to the front fence, the cant rails, B, are hinged to the hind pillar tops, C, and fold back as shown. The dotted lines show the position of the head when up.

The cant rail, merely cut above the front standing pillar, presents a minimum of complication, and is always advisable when the body is a small one. With wide doors and a longer cant rail, when the latter is thrown back behind the quarter it not only juts out beyond the body in an unsightly manner, but it strains the framing of the elbows and hind cross rail to a considerable extent, so that it is often cut and hinged in the centre as mentioned below. The cant rail may be cut either above the front pillar top or behind it, the latter arrangement meaning a shorter piece of hinged rail, although it makes a less satisfactory joint to close, a waterplate being needed to keep the wet out together with a pair of headlocks to strain

the joint home. With the cant rails shutting on top of the pillars all that is needed is a pair of spring catches.

(*b*) By using a similar device to that just described, only the cant rails are cut in the centre so as to fold in two when the head is down and foreshorten it. This method is commonly adopted in many private landaulettes, but the great disadvantage is the gap presented with the open head, which speedily soils the head lining, and for this reason the narrower the body and the less the rise to the roof the better, but there is no reason why a neat cover should not be used as with a cape cart hood.

(*c*) By using mechanism as described under (*a*) or (*b*), and with the front standing pillar tops to hinge as well, thus completely folding down the upper structure of the body. The front pillars usually fold inwards towards the centre of the body, which is always wide enough so that if the pillars are cut sufficiently high above the fence there is no fear of their overlapping one another on the front fence rail. The pillar tops seldom fold forwards, as there is not a handy lamp iron, except in some electric carriages, to form a bearing for the pillar tops when down.

Bodies which open completely are often insisted on by the motorist, who does not realize that he is asking for a folding structure hinged not only at the doors but in eight places above the elbow as well. When the body is wide the folding superstructure is of considerable weight, and not always easily managed by one person, and should the chassis be not absolutely rigid it does not require to be used very long before the opening and shutting of the body becomes unsatisfactory. It is always advisable to have at least a fixed front, which then is practically a drop wind shield, furnished with strong supports, and it is not worth while doing away with the 3-in. thickness of each standing pillar top, which only obstructs the line of vision to a trifling extent, in order to produce a body which cannot give satisfaction for long.

(*d*) By providing a pair of "brougham doors," *i.e.* doors reaching to the cant rail as in a brougham, while a separate pillar top carries the folding head. This is the best arrangement, and has been adopted on all the taxicabs now built, but it has not originated with them, for several "growlers" were so constructed. There being a minimum of folding wood and iron work, it is lighter and

more under control, as well as cheaper. A pair of headlocks are required to draw the head home above the door, and the pillar hinges may be of the simplest design. The adoption of this excellent device in private landaulettes can only be retarded by those who do not wish their cars to be mistaken for public service vehicles.

Landaulettes are usually furnished with a canopy to the driving seat. If the front pillars are made to fold, it will have to be supported on a pair of separate hind stanchions. When the front is fixed, the canopy can be either a fixture or detachable, with a piece of waterplate over the joint. It must be admitted that the fitting of a canopy to any type of landaulette spoils the effect when the hood is open, the carriage then giving the impression of being "all front." Detachable portions of bodies, after having been removable or refitted a few times, are often allowed to permanently remain on or off, and, in any case, the owner cannot conveniently dispense with the detachable portion during a journey, neither would he be inclined to have it sent on to him should bad weather set in during a tour.

Apart from the styles closely following the outline of a brougham, the single landaulette can be made with deep full panels like an old chariot, or follow much after the style of a side-entrance phaeton outline. Round corners to the head give a light appearance to the hind corner, but seldom wear well. The flush-sided body is also being adopted, in some instances, for the structure below the elbow.

*Double Landaulettes.*—The **D**-fronted landaulette is the most popular, chiefly because of the light appearance given by the curved glasses and panels of the front corners, while the passengers on the hind seat have a less obstructed view than with a square front, which latter type, however, gives more accommodation on the front seat. Although the view is less obstructed, objects are usually distorted when seen through a curved surface of glass, a fact which should be remembered when designing other lights and wind-screens. The front is usually recessed at the seat lines, but some builders have designed the front panelling so that it is brought downwards to make a toe, as is usually adopted at the bottom of a front standing pillar, so that the usual toe to the pillar is formed at

the bottom of the front light pillar, and not at the front standing pillar.

With a **D**-front, the light must be fixed, as the constructional difficulties to be encountered in designing a drop light of this shape would not be justified by any advantage accruing. The front, whatever its shape, is not worth adding unless it is at least 8 ins. deep, for the space occupied by a very small front is better incorporated in the width of door and hind quarter. The square-fronted type allows all the lights to drop, and according to the

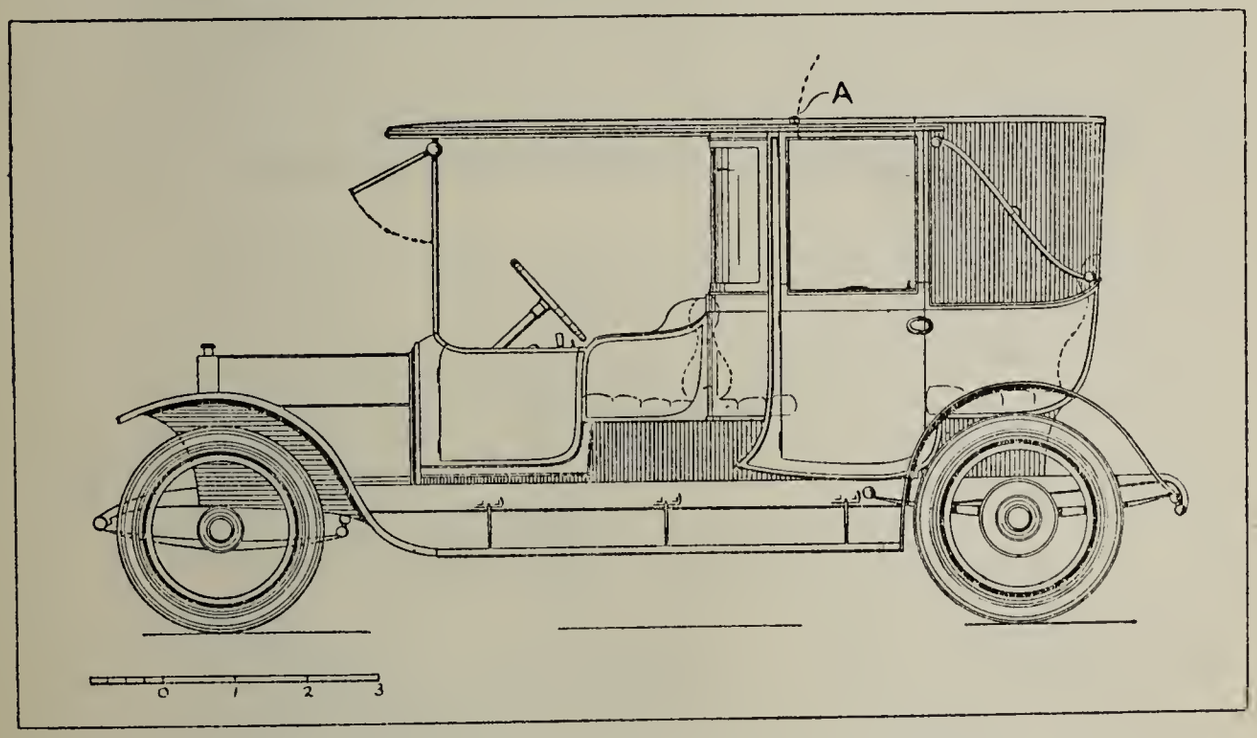


FIG. 11.—D-fronted Double Landaulette. The cant rail opens at A and folds back with the hind pillar top, as in Fig. 10. The rest of the superstructure is fixed.

design of the lower portion of the body, so the depth to which these may fall is decided. When all the lights drop, there follows, naturally, a temptation to drop all the pillars as well, in which case the hind standing pillars fold to the rear with the long cant rail, which must be hinged in the centre, while the front standing pillar tops fold forwards on the front side-light fence, and the front light pillar tops on to the front (cross) fence. Sometimes the front standing pillar tops fold right inwards and downwards inside the body, and the front light pillar tops may fall on a pair of lamp irons.

The fixed front makes the best job, and the opportunity is often taken of fixing a pair of pillar lamps, thereby enhancing the style as a carriage.

The double landaulette, with brougham doors, does not seem to have been thought of by many builders. The most luxuriously hung landaulettes of this type are those turned out by the New Engine Co. The special design of chassis is well adapted to carry any type of large body, allowing, at the same time, the hind seat to be completely forward of the hind axle.

*Limousine Landaulettes.*—This important variety of body first appeared, some eight or nine years ago, as a front-entrance body, and with the advent of side entrances, it naturally had this convenience added to it. In designing the hind-quarter panel, it should be kept at least 14 ins. deep, so as not to appear disproportionate and "lengthy." Above the elbow it should be remembered that in dividing up the space available horizontally, between the

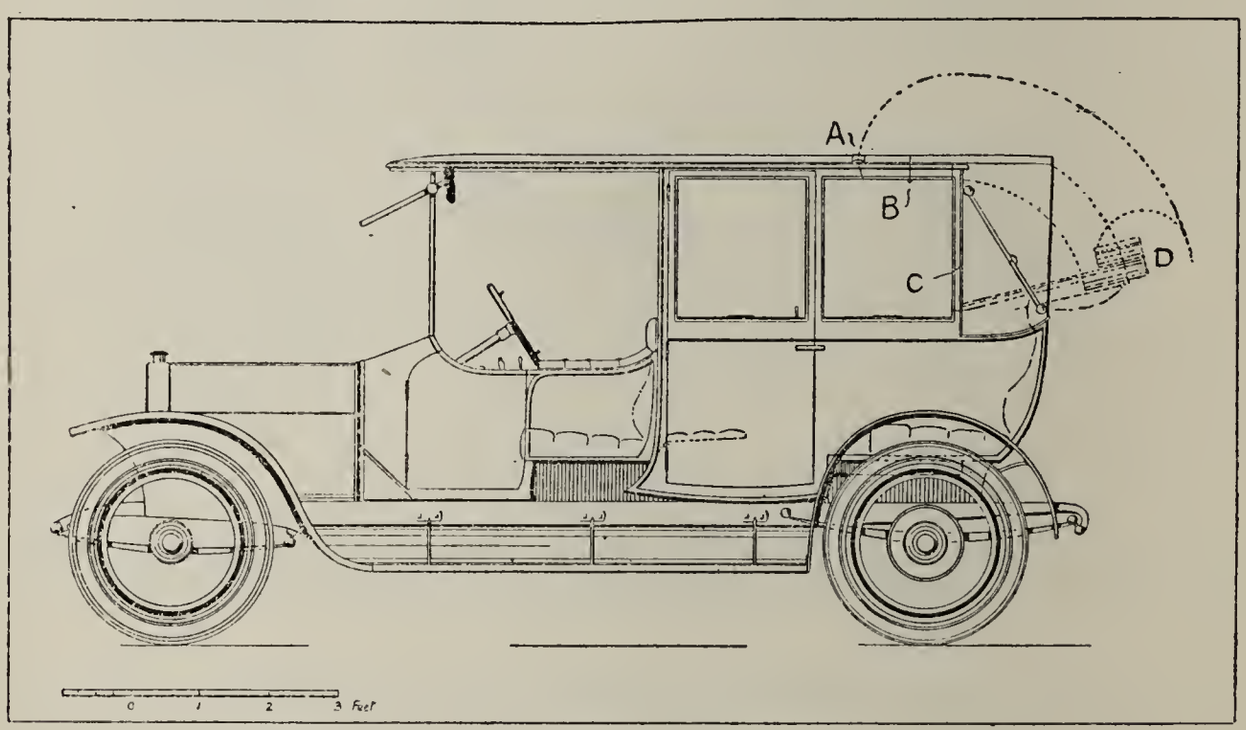


FIG. 12.—Angular Limousine Landaulette, with two single seats on the front lining boards, as Fig. 13. The cant rail opens at A, and is hinged to the pillar top C, as in Fig. 10. The cant rail is also hinged at B so that it can fold upon itself, as shown at D, when the head is down.

back of the door and hind corner, although the side light should not be larger than the door light, the balance of size should be on the side of the light rather than the leather quarter, as the smaller this is the lighter and easier it is to fold. The drop side light, as in a limousine, seldom falls further than the top of the side framing of the seat line.

Limousine landaulettes are built occasionally with all the pillar

tops to fold down, the side light pillar falling towards the rear on the side light fence, the front pillar tops across the front fence, and the rest of the heavy superstructure towards the rear, with the cant rails folding in the centre, and part of the roof may hinge also on to the canopy as is mentioned later under limousines. The limousine style of side light is closely copied in some bodies, the hind bottom corner of the glass frame being rounded, and the cut of the pillar being adapted thereto. The use of a protected front is out of keeping with the general design of the vehicle, and a leather hood is perhaps the best substitute, lying flat against the front when not in use. The luggage space of the canopy should not be extended over the doorway even if the canopy is a fixture, as this throws an unnecessary strain and weight on the body at a weak point.

The fence rails are often framed, and the old solid style formed with "steps" is seldom seen. The fence rail should be not less than $5\frac{1}{2}$ ins. deep overall, otherwise it looks skimpy, but, on the other hand, this dimension has often to be exceeded in order to provide a full drop for the glass frame; but, again, if the designer has a fair amount of depth to dispose of, a deep quarter looks better than a deep fence rail. When the turnunder is large, some builders have adopted the practice of forming a small front panel each side of the front light, so that the drop for the frame is easily arranged, the glass runs being independent of the turnunder.

When the limousine landaulette is used for much touring, or the top is detachable (which is not recommended), the phaeton styles are often preferred. In all landaulettes care must be taken to see that the corner pillar is not too upright, otherwise the line of the head when up will appear to fall in at the top and look unsightly.

*Landaus.*—Although this type of body is unlikely to grow in favour, more attempts might be made to keep the body as compact as possible. There is a greater sociability in sitting *vis-à-vis*, which is a great advantage in the wagonette type of seating, and if the carriage builder could supply this type of body, in an improved form, his services would be appreciated so long as an abnormally long chassis was not required. From what has been done in cabriolet design, there is no reason why the small piece of front cant rail

should not be made to slide in the pillar top, while a foreshortening mechanism could be arranged for either the front or hind folding quarter to assist its compact folding, and no attempt made to protect the driving seat. The side-light landaulette opens up more possibilities, as the cant rails could be made to fold on the corner pillar tops laid on the front fence, while the roof leather of the front quarter could roll up, and the pillar tops be disposed of as mentioned under landaulettes.

Special chassis designed in the direction of, say, 18 ins. instead of 26 ins. between the driving seat and the dashboard would help matters. The great length of a landau body is not only caused by the presence of the front quarter, but the space it requires when folded down. This necessitates a gap of nearly a foot between the main portion of the body and the back of the driving seat.

*Cabriolets.*—The ideal carriage, from the motorist's point of view, is one which shall form, as desired, either a completely open or closed vehicle. From the carriage builders' practical standpoint there are difficulties to be surmounted, in order that the necessary complication shall act well under all conditions, while economy and weight of construction have to be carefully considered. The landaulette, in its various styles, provides for a completely open and closed carriage, but the larger patterns, when made to completely open, have a considerable weight of headwork which is difficult to maintain in effectiveness, especially when the mechanism is continually operated by chauffeurs and others who do not readily appreciate how the folded mechanism is put together and is best kept in working order.

It is not easy at first to see what advantage the cabriolet or landaulette phaeton has over the ordinary landaulette, and in some instances it is difficult to tell where any particular difference lies. The long quarters which some cabriolets have are quite possible on a landaulette, likewise hind rounded corners and roof domed like a cape cart hood; in fact, one style merges into the other at many points. The first patterns, which were designed in France some five years ago, were practically side-entrance phaetons with double extension cape cart hoods, having the added advantage of droplights running in wooden pillar tops. The British builders, in adopting this style, on the whole, did away with the side light,

kept the same over-all length of body by increasing the width of the door and quarter, and giving the body a double cabriolet or victoria outline rather than that of an ordinary side-entrance phaeton.

The leading types of mechanism which have been used up to the present are as follows:—

(*a*) A double-extension cape cart hood folding down in the usual way from the hind centres with drop light behind the driver's seat, and a drop or detachable light in the doors. The front pillar tops fold inwards on to the front fence. This is the lightest form of hood in use, and the front stick of the back portion is kept perpendicular, so that it fulfils the duty of a pillar top.

(*b*) An ordinary landaulette mechanism is used. If the quarter is long, the centre of the pillar joint is thrown well down and back, and may have a double hinge, the raised door light is supported on the usual carriers, the front light drops and pillar tops fall over it.

(*c*) The use of a leather canopy to the driving seat entails a recess being formed in the top front rail of the body, in which the canopy with its supporting side joints (folding inwards horizontally) lies when not in use. The front rail of the canopy above the wind screen is provided with means for attaching it thereto, and also to the front top rail of the body. The canopy may also be supported on slides working from the inside of the cant rail. The slides support the leather work in conjunction with light hoop-sticks. The canopy in its simplest form may be merely detachable or to roll up, and it has been arranged also on the spring-blind principle.

(*d*) Bodies with extra long quarters may have the front stick slanted, as in a victoria, while a loose flap covers the space between this slat and the upright pillar top. This pillar top is hinged to the stick and cant rail at the top, and fastens at the bottom with a catch at the fence rail. Folding cant rails are utilized with wide doors as in landaulettes, and with greater disadvantage as the sweep given to the roof is more pronounced. This defect in earlier types has now been modified by hingeing the cant rails to fold inwards horizontally.

(*e*) In order to gain lightness in the doors, the device has been tried of hingeing the door lights to the front light, so that the

door lights being folded on to the front light, the whole could drop into the front glass-run. The extra weight is raised by means of a rack and pinion (a type built by Messrs. Salmons).

(*f*) The fully enclosed car, shown by Messrs. Mulliner of Northampton at Olympia in 1909, was a double enclosed car, in which the front doors opened from dashboard to the standing pillar of the second pair of doors. The larger doors revealed the driving seat, this being necessary to avoid the use of another vertical pillar which would have to fold, besides meaning two lights instead of one, and also giving a less interrupted view. The other door lights dropped in the usual manner, the cant rails over the driving seat hinged inwards in the centre, likewise those over the smaller doorway, which together with the front top rail of the body and usual hind pillar and slats all folded back to the rear, while the front standing pillar tops were disposed of in the usual way, across the front fence.

Among other features which may be noticed in the various patterns of cabriolet hoods are, that the cant rails may slide down the pillar tops so as to foreshorten the open head, also that the front light may be directly hinged to the front top rail, while the canopy may be supported on a small folding metal framework instead of head joints, or if the canopy be detachable, it may be sewn to a light set of slats so that it shall keep its shape when in use.

The door lights of most cabriolets are short, which is owing to the fact that the head leather is brought well down to a comparatively low cant rail, and the fence is kept high. Short lights are usually necessary if they are to drop their full depth owing to the turnunder of the door.

In an early French pattern a hood to the front seat first collapsed on the face of the front pillars, these latter lifting over and falling from a hind centre, as in a cape cart hood. Another style had the pillar tops to fold on the front fence, the door cant rails to hinge inwards and falling back with the hind standing and light pillar tops, the central hood supports being of metal to ensure compactness and working on the lazy tongs principle. It is curious to note that the *caléche* of 1870 had much of the cabriolet principle of headwork.

The latest type of cabriolets are built much on the lines of a flush-sided phaeton, and the head mechanism tends to be simpler.

It has been found that by raising the hinge centre which is necessary at the cant rail, a device can be obtained which allows the cant rail to automatically throw back without being reversed or folded. Much compactness is obtained in this way, and there is no need for any sliding parts. Simplification is obtained by having one side entrance instead of two and making a pillar top wholly detachable instead of hingeing it.

*Limousines.*—This popular type of closed carriage may be constructed in various styles, from the small *coupé* limousine, just holding two in the body, up to the large seven-seated car replete with every travelling convenience. The side light is a leading feature in this body. It generally drops in one piece, the practice

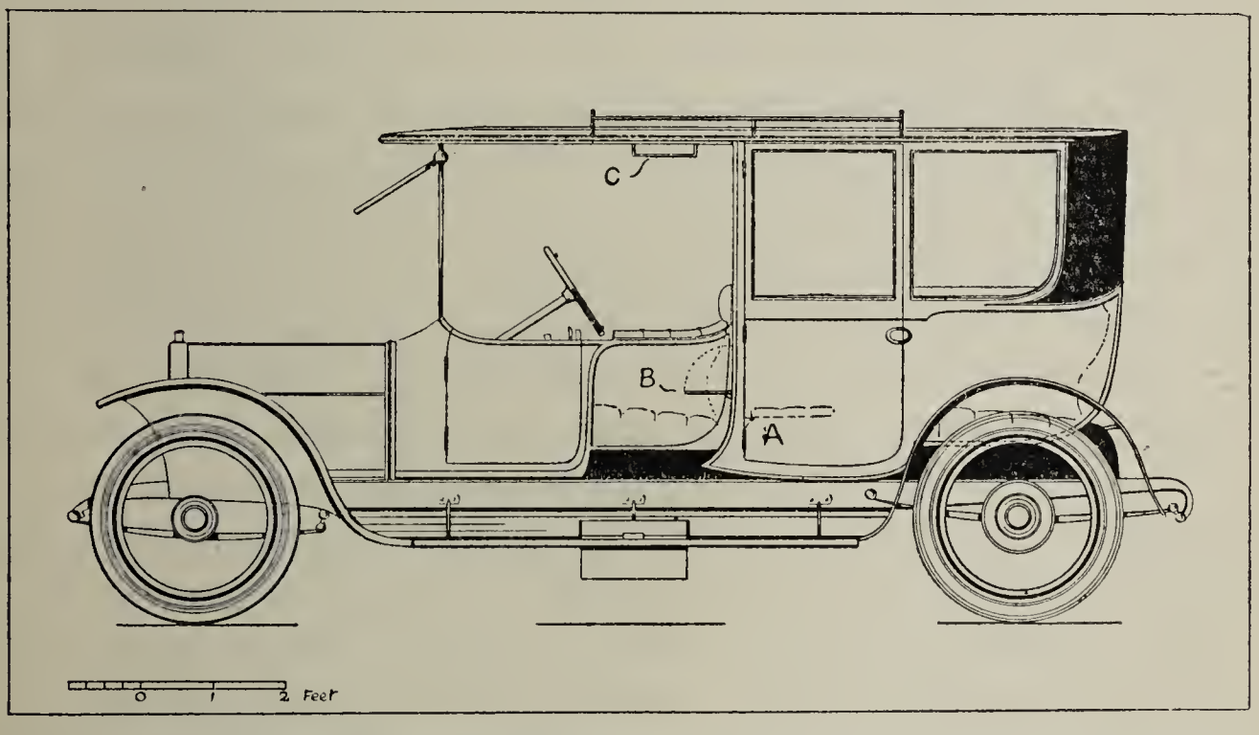


FIG. 13.—Limousine with two single seats, A, screwed to the front lining boards. B is a folding step to the roof, and C the ascending handle.

of dividing it into two portions being seldom adopted now. This light generally starts immediately behind the standing pillar, and is designed to leave sufficient upper panelling just to cover the face, when sitting well back. The back light is generally a large fixed one, and is seldom used merely to break up the surface of the hind panelling. The plan has been tried of designing the side windows so that a look-out arrangement is provided as with the observation window of a railway guard's van.

In designing the light, care should be taken to keep the back line slightly out of the perpendicular, and leaning towards the

throw-out of the back panel. The top line of the light follows that of the door top merely for the sake of symmetry. The side light seldom drops its full depth, and is allowed to rest on the framing at the seat line. By providing a ventilating rail, a good deep panel, and a special wooden pocket below the seat, the light can be dropped its full depth.

In a limousine, one sometimes sees a clerestory roof adopted, which helps the vitiated air to escape more readily. The body is seldom constructed without a canopy, except in the smallest sizes. As the usual sweep of the cant rail narrows towards the front, it is necessary for the outside line of the canopy to sweep out again in order to give proper protection to the driving seat and be of sufficient width to take the flaps of the front stanchions, which should embrace a wind shield at least the width of the driving seat on its front edge. The luggage rail should be restricted to the canopy or placed centrally on the roof, as this distributes the weight better, besides the necessary handles and ascending treads can be more conveniently fitted here. The luggage rail itself should be neat and not more than 6 ins. high, while fancy scroll ends should be used with moderation. The driving seat should always butt up to the main portion of the body, so that no difficult surface to clean is presented; if separated it must be hinged on the front edge. A style of decoration often seen consists of the use of a narrow vertical panel at each hind corner.

The limousine has been made to convert into a partly open carriage by various means. In the Gamage-Bell cab the cant rail is cut in the centre over the side light, and the corner pillar is hinged above the elbow so that these members of the framework, together with portions of the roof and back panel, can hinge down and backwards, while a stop hinge assisted with a quadrant each side prevents the folded headwork from going back too far. Another method is to fold a portion of the roof forward on to the canopy, while Mulliner of Northampton showed a body at an Olympia show where the roof folded over twice on to the remaining roof portion at the rear. A simpler plan, which gives adequate ventilation, consists in hingeing up into the roof the hind standing pillar top.

The limousine gives great scope for the provision of luxurious

interiors, and a D-front may be added to the design, simply to introduce special cabinet work.

The use of a protected front to the driving seat has been growing in favour of late. It should be framed as lightly as possible, so that the general design has nothing of the railway carriage about it, and a good plan is to use a metal curved front stile, while the elbow should be no heavier than such dimensions as will easily take a rebate for the glass. The protected front, besides giving a finish to the body, provides another support to a luggage-carrying roof.

Detachable tops are fitted, in a few instances, to limousines, but they do not grow in favour to any extent. Careful fitting is necessary, and a phaeton outline must be given to the lower part, in order that it shall look well when used as an open carriage. The use of a straight ledge, on which to fit the upper part of the body, has been advocated, the raised back to the hind seat being recessed sufficiently to allow for the thickness of the top panelling and framing. A detachable top requires staples fixed in the roof, properly arranged, so that the body when lifted does not tilt appreciably in any direction, a point to be considered if the motor house is small. A simple plan shape is advisable, if a satisfactorily working top is to be made. Drop windows complicate matters, and should be avoided as far as possible, the hingeing window being the best compromise. Loose rolls to the elbows and back squab can be fitted, which add to the comfort of the body and may also hide the glass runs in the lower part. The body on no account should have the top fitted to conceal overhanging rolls.

A cape hood may be mounted to take the place of the solid top, the body props for this purpose being made detachable.

The detachable top has little to commend it, as it means a heavier and more complex structure, with the main disadvantage that windows cannot be arranged so simply, while the doors have to be made in two portions.

One may often see a four-seated body with a full-panelled driving seat, while the hind seat is recessed at the seat line. This style tends to direct the attention chiefly to the front of the body and make it appear heavier and more important. More

symmetry is gained by either having all full panels, or restricting them to the rear. This point of view is of some importance, as the owner seldom drives a limousine.

*Single Enclosed Cars.*—When the engine is of small horse-power the superstructure should be as light as possible, so that one often sees light cape hoods, instead of heavy leather ones, and drop-lights dispensed with as far as possible, so that the lower framing may be of minimum dimensions. The two-seated car with a solid top is sometimes called a "sedan chair" body, as the seating arrangement calls up that old-fashioned mode of travel. The front wind shield has the advantage of the strong front framing of the body to

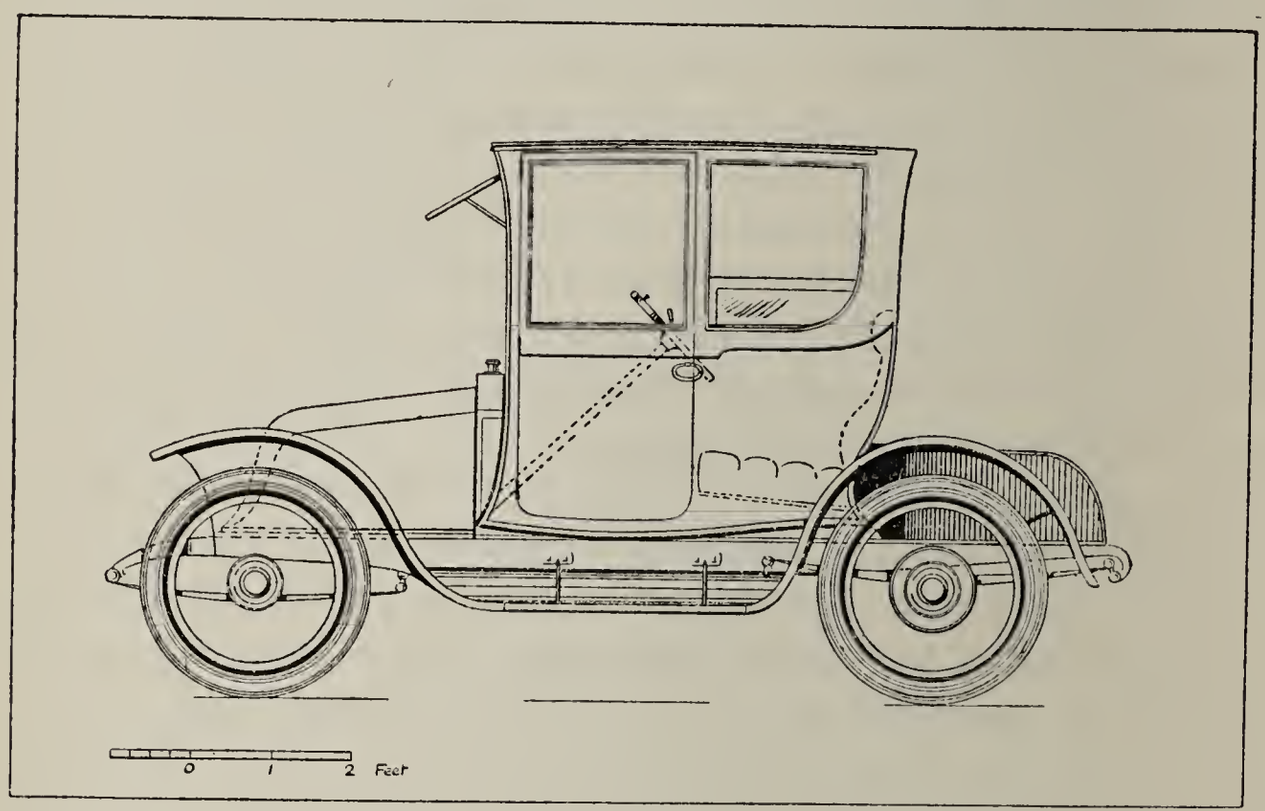


FIG. 14.—Single Enclosed Car, with tool box at rear. The side light is shown down to its fullest extent.

support it; it is usually mounted on a curved dashboard, and it is seldom possible to fit any form of drop light. A larger type of body has a gangway at the side of the driving seat leading to a comfortable seat for two at the rear. This double-seated single entrance arrangement requires a longer and more powerful chassis, and is gaining somewhat in favour owing to the sociability it gives in a self-driving car.

In the ordinary two-seater, with high wind doors, it is not obligatory to place the levers inside the body, but when a top is

fitted this must be done—another factor which increases weight, demanding a top as light as possible.

The front wind shield should be protected from the rain either by projecting the roof forward to form a small canopy, or providing a special calash.

There is ample opportunity, in a car of this description, for designing a graceful and well-balanced little body. An extra sweep to the roof from end to end, the top out-curving of the standing and corner pillars, an easy flowing line from the elbow to the toe of the front standing pillar, and a bold outline to the side and backlights, can easily be combined, without elaboration, to give a design both stylish and pleasing to an artistically inclined customer.

The landaulette top presents its own peculiar restrictions; the leather surfaces must on the whole be as flat and as simple as possible, and the body should not be built so long that cant rails have to be hinged in the centre, although this may be advisable if a folding dickey seat is used at the rear.

As mentioned under solid tops, the body may have a separate hind seat inside, when it is not unusual to add a side light to the design so as to keep the folding head small. It is unnecessary to build up an expensive D-front above the curved dashboard, as the wind screen is quite as effective when supported on the back edge. The front pillar should be a fixture, in order to provide a good support for the wind shield, but if no top hinge is used, the top half of the pillars may fold downwards, allowing the top half of the screen to work from a separate joint.

Some builders have mounted bodies, having a seating arrangement which includes a small seat on the dashboard, usually with the seat back to the doorway, and in order to maintain the knee-room of the near-side passenger of the main seat, it is built back about 3 ins. from the front line of the driving half of the seat. The space left at the back of this seat can then be arranged as a gravity petrol tank.

*Double Enclosed Cars.*—The most luxurious body of to-day is the car body which has seating for four to eight passengers with separate doors to the driving and hind seats, and sometimes a central door or corridor arrangement leading from one part of the body to the other. The various considerations mentioned under limousines and

landaulettes apply, and as the chassis is taken for granted to be of ample power, the weight of the body, which is inseparable from its design, is not seriously taken in account. The use of a D-front above the dashboard balances the rounded hind corner, while roof ventilators and louvres just below the cant rail are often adopted to further ventilate the body. The design needs to be boldly treated, and should be executed so that the car does not look like two bodies

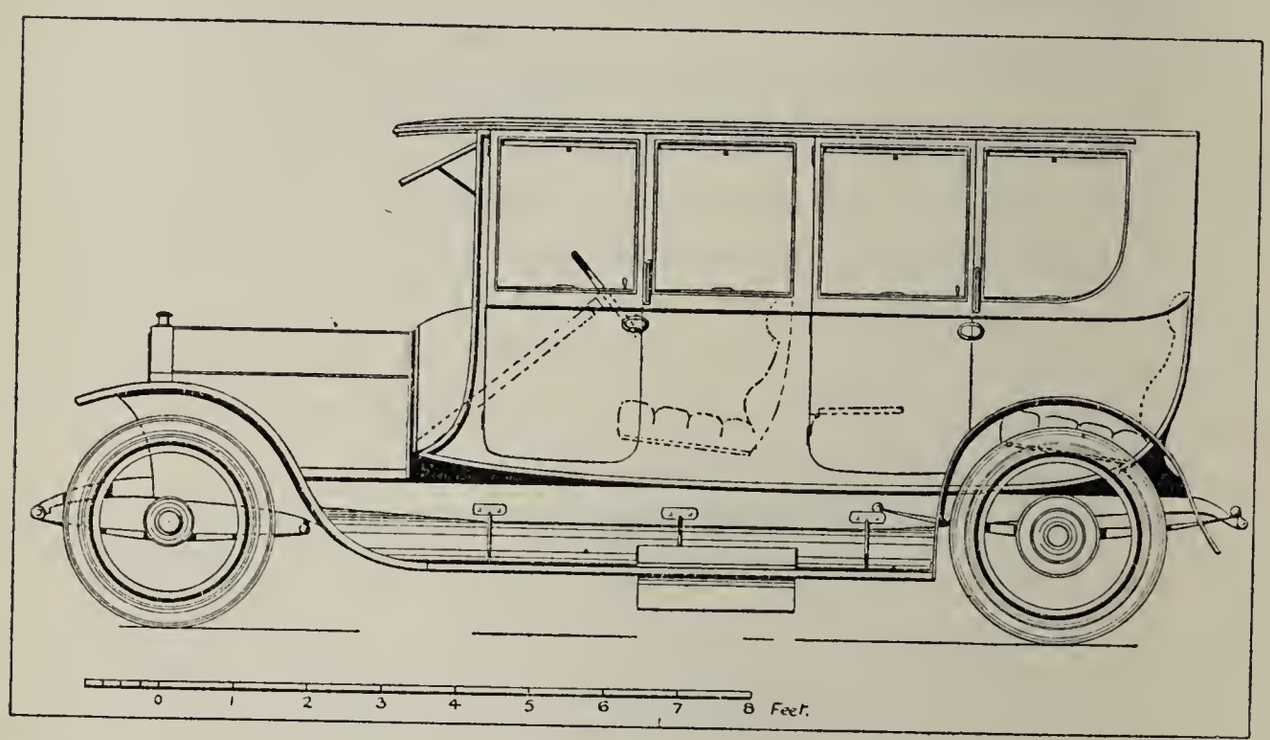


FIG. 15.—Double Enclosed Car, with two single seats on the front lining boards, as in Figs. 12 and 13.

stuck together. Owing to their size, detachable tops are seldom fitted, but tops to lift off in two separate portions have been constructed.

The double enclosed car may be used as a partly open car by constructing a folding hood at the rear, while various pillar tops may hinge into the roof in order to give some of the advantages of an open phaeton. The disadvantage from the purely artistic point of view is that the body looks heavy in front when the hood is down. The enclosed car has risen in favour since 1907.

*Wagonettes, Shooting Brakes, and Luggage Cars.*—This type of body fulfils the requirements of the sporting dogcart, and generally has sufficient capacity to replace two of these horsed vehicles. Its seating plan follows that of a horsed wagonette break, with the added advantage of a much lower body.

Side entrances materially detract from the usefulness of the body, as the seats, if fitted to these doors, have to be made to fold up separately.

A wide hind entrance should be adopted, and if luggage is often to be carried, one wide and one narrow door should be hung, so as to provide, say, a 30-in. double door, through which the luggage may be easily passed. A wide bottom to the body is not customary, but it increases the loading capacity if a wide chassis can be

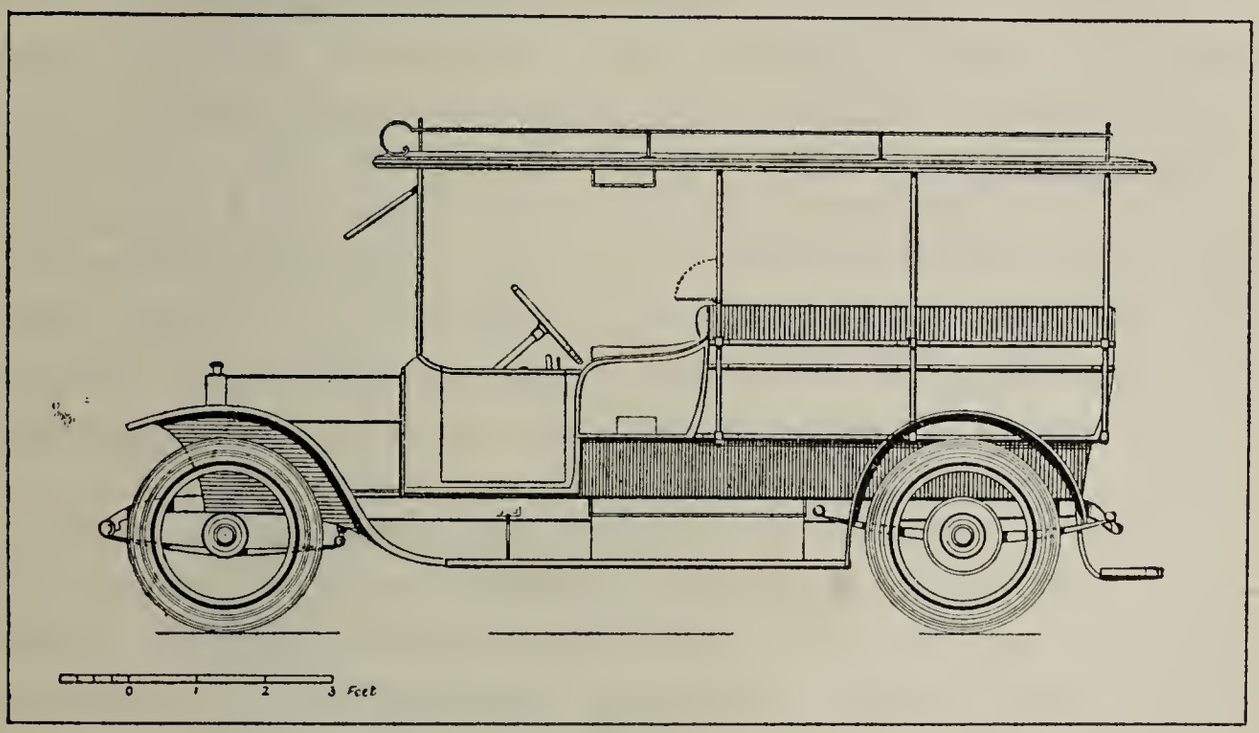


FIG. 16.—Shooting Brake, Wagonette or Luggage Car, with hind entrance.

obtained. Folding seats are now in vogue, so that the body may be converted into a non-passenger vehicle, either as a whole or in part. The locker space of the body may be increased by adding outside boxes on the step, and on a pair of flat hind wings, but it would certainly appear to be better design to incorporate the required space in the body itself.

One is almost forced to the conclusion that apart from various models of chassis, from the horse-power point of view, and various means of transmission, there is some scope for manufacturers to specialize on types adapted for wide bodies with wide tracks, if they do not find it remunerative to build such patterns as one of their ordinary models.

In designing the outline of the body the practice is to use straight lines freely, so that a workmanlike style is obtained.

The back panels may have a moderate turnunder, but it should be remembered that if the door is to open square every fraction of an inch more turnunder means a longer and stronger hinge to the lower parts, and heavier framing to hang it to. The canopy stanchions should be double socketed with a good vertical distance between the bearings, so that they are held rigidly. The body may be panelled up either to the elbow or to the top of the back rest, which should be normally 22 ins. from the seat board.

*Lonsdale Wagonettes.*—When side-entrance landaulettes became possible on petrol chassis, this hind-entrance type of landau naturally fell into disuse. It is a far more compact body than a four-seated landau or even single landaulette, and the style of body can be easily made more artistic, as there is no call for the severe lines used in a shooting brake or omnibus. The width of the head, when down, has to be taken into consideration, for which reason the half cant rails hinge inwards from the pillar top. The back framing should be well plated, as there is a large amount of weight carried when the head is down.

*Private Omnibuses.*—As in other wagonette bodies, this type carries its load with the shortest possible length of chassis, and is useful for station work, in hilly districts, and in any circumstances where a large load has to be carried economically, and convenience of entry is not the main consideration. The body may be as long as the varying lengths of chassis allow. The seating capacity is seldom increased by transverse roof seats.

The design of bodies from the constructional point of view is dealt with in Chapter VII.

*Locker Space.*—An important factor in the design of a motor body is the space allowed for tools, spare parts, luggage and the various accessories incidental to comfortable road travel. The modern flush-sided body helps to increase locker accommodation so long as the seats are moderately high, but even when a seat is some 9 ins. or 10 ins. from the floor the whole space under the front seat may be taken up by a petrol tank. When the back seat is a low one, it is a somewhat perplexing situation to arrange the car for carrying something else besides passengers. If the body is long a space can be arranged between the back of the driving seat and the doorway; if a locker can be made under the hind seats it will be

an added convenience if it can be got at both from inside and out, but with a full-panelled body the designer is loth to mar a beautifully curved surface with a rectangular opening in the lower part, but utility has often to give place to artistic considerations.

The long side steps are used for fixing tool, accumulator, and generator boxes, spare wheel rims, flanges, tyres, and so on. Drawers under the steps are often seen, but a better method is to use part of the step itself as the lid of the locker, and then no alterations in climatic conditions or careless washing of the car will cause drawers to bind, although wet is liable to enter in either case. The step is best fitted with a metal depression, if a spare wheel, or similar equipment, is carried, as this helps to make this accessory less significant. Lockers can also be devised in a special extension of the hind seat framework with a door opening from the rear, which may be just the size to take a spare wheel, or be divided with a lower drawer for the same purpose, and upper cupboards and smaller drawers for tools and other items of the equipment such as curtains. The two-seated car has a natural large locker space, and all limousine types and bodies provided with a canopy have a large area for the disposal of trunks and similar contrivances. Lockers beneath the floor, between the spaces of the transmission mechanism, have been tried, and also above the bonnet, but the latter has little to recommend it on the point of accessibility. A luggage grid is the usual accessory called for in all types of bodies, whether they are well equipped with locker space or not, and it is generally hinged to the hind bar of the frame, either as a whole or in two portions with a pair of suitable stays to take the strain and help to keep the luggage on the grid. The large tool box, hung from beneath the back of the chassis, has fallen into disuse, because the petrol tank is usually slung here. Trunks and baskets are made to fit into seat lockers so as to be removable and kept clean as a whole for taking into a hotel. Trunks are made specially to fit the back of the body, the roof and canopy, and inside the spare wheel. Tool boxes, and drawers, opening from the outside, should be provided with good locks, and not the pattern which can be opened with a square key, which is inviting the pilferer.

# CHAPTER V

## *THE COACHBUILDER AND THE MOTORIST*

The motorist has not always made up his mind as to his requirements concerning the coachwork, although he usually has several ideas which he is anxious shall be incorporated in the body to be built.

*Who shall have the Order for the Body.*—Some, of course, will visit a showroom and buy a complete car there and then, but those who wish to express an individuality in the body work mounted will find some useful advice, it is hoped, in this chapter, and hints are given which will save time and money, and give satisfaction to all parties concerned. There is more than one channel through which the body may be ordered. Some go to the motor manufacturer who has a coachbuilding department of his own, or who engages an outside motor-body builder to do the work, others go to the hundred and one agents who sublet the work, while that class who desire the utmost value for their money and wish to get in direct touch with the builder, go straight to the motor-body builder, a practice which King George and his illustrious father both have pursued.

The excuse, perhaps, for putting the matter in the hands of an agent is to confine one's transaction to one invoice and to have one salesman only to deal with, but it requires but little consideration to show that the body builder, if he constructs for the client through a middleman, has to be satisfied with less profit, while if he is able to charge a higher price, he would gladly spend money on better class materials and finish. Also, instructions which have to be handed from one person to another lose some of their exactness, a point which may be often proved by the client himself interviewing the coachbuilder, even when he is buying through an agent who is

getting 20 to 25 per cent. for doing nothing practically, and certainly taking no responsibility.

*The Claims of the Coachbuilder.*—When the motor manufacturer has a reputation for his coachwork, such as the Daimler, Austin and Wolseley firms, it is no doubt a good plan to buy the complete car from them, but if the firm from which the chassis is purchased do not build bodies, then it is far better to go straight to the coachbuilder and obtain an interview with the principal. It will save time, all matters can be gone into, bodies of a like nature will probably be seen in the course of construction, while patterns of cloth, lace, and paint may be inspected, and suggestions from each side discussed and settled by a practical man on the spot as to their feasibility. It will cost no more, probably less, and the car may be taken delivery of at the place where it is finished, so that its completeness when compared with the estimate can easily be ascertained.

Motorists who may be expected to go to an agent for their coachwork are those who have never bought a horse carriage. Probably they are ignorant as to the names and addresses of suitable firms. They should then consult a friend who has the wider knowledge necessary, or, failing personal recommendation, recourse may be had to a directory; but surely any man with the means necessary to run a car knows, if he is a London man, the whereabouts of Hooper's, Barker's, Holland and Holland's, Thrupp and Maberly's, Rothschild's, and many others; or if he is a Liverpool man, of Lawton's; of Manchester, Cookshoot's, and so on, almost indefinitely. Orders should be placed locally where possible, and the small man is often a genius, although he may not have an elaborate showroom.

It has been stated that the body builder has ideas of his own, which he will not depart from, except under pressure. A leading coachbuilder once said to the author that he was willing to build a body upside down if necessary, and one continually hears of the coachbuilder building bodies, largely of an experimental nature, in order to carry out faithfully the wishes of the client. It will be remembered also that most body builders have ridden a fair amount themselves, a plea which could not always be truthfully put forward with horse carriages.

*The Time Factor.* — The motorist should have previously decided the type of body he requires from the illustrations and descriptions given in the chapter on the design of motor bodies, while the question of colour can be decided from the tables given in Chapter X., and usual accessories needful will be found in the chapters devoted to them. If he is in a great hurry for his car, it may be at once stated that dissatisfaction is sure to arise subsequently. No well-finished body can be built and painted under eight or nine weeks, or six weeks if the body is already in the bare wood and iron.

*The Blue Print and Sketches.*—The coachbuilder must be provided with a reliable blue print if the chassis cannot be delivered forthwith, but the chassis must be forthcoming within three weeks of the finishing, otherwise there will be a vast difference in the painted surfaces of the body and chassis. Delivery of the complete car is best promised as so long after the delivery of the chassis. The time question having been satisfactorily settled, an outline sketch of the job is asked for, which should show the elevation to 1 in. or 1½ in. scale ($\frac{1}{12}$ or $\frac{1}{8}$ full size), with perhaps a plan of the seating dimensioned in its main features. This sketch should be retained after final approval, the coachbuilder having a tracing or other copy from which he gets out his full-size drawing for the body maker.

If a coloured drawing is asked for, the motorist should be willing to pay for this, if he retains it and does not accept the final estimate. No particulars of the estimate should be left to verbal instructions, everything should be written down, so that the oft-disputed question of extras shall be absent when the time comes for payment.

*Visits during Construction.*—A motor-body builder who is not ashamed of his methods of construction and the selection of his material, will gladly allow his client to see the body during construction. A diplomatic visit may be made, say twelve or fourteen days after giving the order. He will then get a good idea as to the type of framing used, the fixing of the panels, and the neatness of the joints. The visit should be made only for the purpose of judging the workmanship of the body, and not as an opportunity for deciding on something different. If the client is dissatisfied with a piece of timber used, he should say so, for if he is mistaken, the matter will

be explained. A more essential visit is during the process of trimming, for then the future occupants of the body may judge of the restfulness and adaptability of the seats, which can be adjusted to individual requirements exactly now, a difficult and tedious matter when a highly finished varnished body is being dealt with. Every motorist who is jealous of the comfort given by the upholstery, should ask for an appointment when he may try the trimming, and half an hour spent with the manager and foreman trimmer will mean time well spent and many thousands of miles of comfortable travel. The back squab should fit snugly to the back and shoulders, and the cushion should not only be soft and full of life, but have the tendency to force one to use the back support. The comfort of the feet should be noted; if there is any straining, probably the seat is too high. If the appointment has been wisely made, it will not be too late to lower the seat, but the drawing furnished with the estimate should state the height of seat plus that of the cushion, so that this may be compared with a comfortable chair at home.

Having been satisfied with the trimming, the motorist will be showing his discretion if he leaves his next visit until the date mentioned in the estimate for completion. Any interference while the painting is being proceeded with, will probably be resented, as the processes are delicate, and require to be surrounded by those who know by experience how to guard the drying surfaces. The motorist will find all that goes on, during his absence, in the chapter on painting.

One who also will be interested in the completion of the car is the chauffeur, who will probably wish to appear on the scene before the final coat of varnish is applied, so that he may have a look at the chassis.

The owner, however, should see that his servant is not guilty of this kind of aggravation. The chassis may be inspected, if necessary, before the mounting or during the preliminary stages of trimming. It is understood that the final tuning up of the mechanism has already been accomplished, although some motorists willingly pay an extra fee after the body is mounted and finished. The only matter which may present itself at the conclusion of the work is that the body is not suited to the chassis, which will only happen because the motor-body builder's advice has been over-ridden on the

subject of wheel base, chassis length, hind springs, position of steering wheel, and other elementary matters of a like nature.

The chauffeur then should be able to fill up his tanks and switch on his ignition and start straight away when the eventful moment comes. His presence may be advisable after the varnish has hardened and when accessories are being attached, so that he may have his hooter, speedometer, outside tool box, and other items put where they will be most handy.

# CHAPTER VI

## *MOTOR BODY DRAWING*

As little has yet been written which has for its object the assistance of the motor-body builder's draughtsman, it is hoped that the following outline of the subject will be of particular interest to those who wish to prepare sketches and working drawings of the various kinds of motor bodies.

The drawings which are executed in the carriage factory consist of scale drawings in ink or pencil, in outline, plain or shaded, ranging from scales of $\frac{3}{4}$ in. to the foot up to $1\frac{1}{2}$ ins. to the foot, and larger scales for detail work; tracings of these drawings for reference purposes, and for making blue prints; and full-size working drawings for the body maker's and sometimes smith's use. On rare occasions coloured drawings, in elevation and perspective, are done to show the prospective client the general effect of his proposed car.

*Instruments.*—The instruments used should be of the best quality, as naturally they are more satisfactory in working than common ones, a vital matter to the draughtsman who cares for the quality of his work.

If a set of instruments is bought in a case, the compasses and other items can be kept in their proper places in it, but it is more economical to buy the various tools as required separately, for in an expensive case there are likely to be several things which will be seldom or never used in the ordinary course of work, while a small box or case can afterwards be procured for keeping the tools together. The following is a general list of tools required :—

A pair of German silver, best-quality, needle-pointed, long-jointed, 6-in. compasses, with divider, pen, and pencil points,

lengthening bar (for drawing large circles); knee joints throughout; costing about 16*s*.

A set of spring bow compasses, comprising a separate divider, pen and pencil compass, with needle points, in case, costing about 12*s*. Longer-legged sets may be had for another 3*s*., but the range of the 6-in. compasses will include the larger size circles of the longer spring bows, therefore the smaller spring bows will be more useful.

A good drawing pen should have a hinged nib, so that it may be easily cleaned. The quality of the handle is a very secondary consideration, although one often pays as much for it as the other part. A good pen can be obtained as low as 1*s*. 6*d*., the higher-priced ones having ivory handles, which are less liable to break when dropped, instead of bone ones.

It is better to buy two or three cheap pens with useful nibs, rather than buy a single expensive one, as the draughtsman then has no reserve pen.

A useful scale-rule is made of boxwood, oval in section, is 12 ins. long, and has accurately marked on it all scales ranging from $\frac{1}{8}$ in. up to 3 ins. For converting French into British measure a metre stick, marked one side metric and the other inches and parts of an inch, will be found of great service. Two or three drawing boards will be required, according to the variety of work done. An imperial size is useful for $1\frac{1}{2}$-in. scale work, a half-imperial for 1-in. scale work, while foolscap size is handy for any smaller work executed. There are several ingeniously made boards which are designed to resist altering in shape to the slightest extent, so as not to detract from the accuracy of the T- and set-squares used, but they have the disadvantage of being bulky, and a carriage draughtsman does not work under quite the same rigid conditions as an engineer's draughtsman, for in dealing with curves in the preliminary sketch, he will require to move his board often, in order that his wrist (and not the French or other curve) shall have full play. It is necessary, however, to pay a good price, and go to a reliable house for one's drawing boards, as seasoned and faultless timber is absolutely essential.

The cost of three boards with clamped ends, sizes 31 ins. by 22 ins., 25 ins. by 18 ins., and $15\frac{1}{2}$ ins. by 11 ins., will be about

7*s.* 6*d.* They should be kept in a dry place, a remark which applies to all the tools, and the paper as well. Engineers' drawing boards with mahogany battens fastened to brass slots, will cost about 18*s.* for the two larger sizes.

A T-square with a blade wider at the head is stronger constructionally for the size of blade used than if it were parallel, but the latter type is at times more useful. A mahogany T-square with ebony edge should be available for each larger size board used, the blade overlapping the length of the board slightly. The pearwood T-square for the small board will cost about 9*d.*, mahogany ones for the others, 4*s.* 6*d.* and 5*s.* 6*d.* respectively.

A pair of set-squares may cost anything from 3*d.* (pearwood) to 15*s.* (framed in mahogany skeleton, with ebony edges). A large protractor will be handy for plotting the rake of steering columns. A semicircular brass one will cost about 7*s.* 6*d.* The rectangular boxwood protractor and parallel rules are of little use.

For full-size drawing, straight edges will be required, and if not made in the shop, may be had in mahogany and pearwood. The most useful lengths are 3 ft. 6 ins. and 6 ft. The pair of mahogany ones will cost 10*s.* 6*d.*, the pearwood 5*s.* 6*d.*

If the draughtsman has control over the making of the full-size drawing board, he should see that it is made of sound pine, about 15 ft. by 7 ft. 6 ins., with a large T-square hanging from the top. The drawing board should be painted dead black, so as to be available for chalk work, but it is desirable to do the majority of the drawings on paper. Paper up to 90 ins. wide may be obtained cheaply in rolls, and is usually sold by weight.

The curves required for the full-size work will be the actual, or copies of the patterns used at the bench and in the saw mill, and got out by the body maker. For scale-work boxwood ones should be cut out on a treadle fretsaw, and then filed and sandpapered up from the freehand outlines transferred to them, such as are suggested by the outlines of the work done. If the draughtsman will trace the curves in, say, a dozen different kinds of bodies, he will find that parts of many of the lines are duplicated, so that, with a little ingenuity, one pattern will give a considerable amount of service. A pattern thus made up should not be more than 9 ins. or 10 ins. long, and $\frac{1}{16}$ in. thick, with bevelled edges on both sides.

Both long edges may be used for varying outlines, and the pattern should be left solid, that is, no attempt made to utilize it for interior work, which will weaken it. Twenty-five well-thought-out patterns will be sufficient for the range of work done in most offices, and will cover $\frac{3}{4}$-in. to $1\frac{1}{2}$-in. scale drawings.

Drawing pins are less dangerous when the shank is punched out and turned down from the head. A gross at 1*s.* 6*d.* will last a couple of years or less, according to the number of borrowers likely to visit the office. Most brass pins are finger-nail breakers.

Large circles and arcs in full-size work should be done with beam compasses. A 36-in. T-section oak beam, and German silver compasses in case, will cost 16*s.* 6*d.*

Rubber for removing pencil marks is best purchased in sixpenny blocks. It should be soft, so as to wear itself out rather than the paper. A sixpenny piece of hard ink eraser is preferable to the use of a knife for removing ink and colour work.

Pencils used vary in price, according to who provides them. A silky Koh-i-noor is a delight.

For inking in, a vellum surfaced saucer and stick of ink will be required. Bottle ink saves time now and then, but, as a rule, does not flow so well through the pen. Two 4-in. saucers, say, 1*s.* 6*d.* the two, a stick of ink at 9*d.*, and a brush at 4*d.* should be purchased. A water glass at 6*d.*, which is not so liable to get knocked over as other receptacles, will also be found serviceable.

The above list will be sufficient to give a general idea. Additions will be made according to the temperament and circumstances of the worker. Whatman's paper should invariably be used for scale work, which may be had in hot-pressed, or smooth, natural grain, and rough surfaces, and in various thicknesses (weight per ream). Nothing is quite so helpful in keeping the draughtsman enthusiastic at his work as a good quality of paper. The hot-pressed surface is best for pen and pencil work, and Bristol board when special jobs are being done, or for coloured work. The advantage of good drawing paper or cardboard is that the eraser does not spoil the surface.

It is best to work on a board which is tilted about 2 ins. with a block of some sort, the remaining portion of the table being flat, so that tools lying around stay where they are placed. The bottom

edge of the work, and the level of the chair seat, should be about 11 ins. apart vertically.

*Scale Drawing.*—The student must fully understand the use of the scale rule, and be able to draw out any given scale should he not have a prepared one available. An inch scale represents for each actual inch one foot, and the first left-hand division is subdivided so that each one-twelfth part represents an inch. To take off, say, 3 ft. 4 ins., the rule will be laid on the paper, and a pencil mark made at the division marked "3," and to the left at the fourth subdivision counted from the left of the division marked "0." The dividers are also useful for taking off a measurement from the rule, especially when several lengths of the same value are wanted at the same time. With a scale rule, which has several scales on it, the subdivisions of one scale will read from the left, and the other from the right-hand end. When each inch on a scale represents a foot, it is also described as a scale of $\frac{1}{12}$, a half-inch scale as $\frac{1}{24}$, three-quarter inch as $\frac{1}{16}$, and so on, according to the value of the represented to the actual foot.

Blue and other prints representing foreign chassis are often drawn to $\frac{1}{5}$, $\frac{1}{10}$, and $\frac{1}{15}$, being a convenient reduction on the metric scale. If a scale is made in feet and inches to $\frac{1}{5}$, $\frac{1}{10}$, and $\frac{1}{15}$, it will reveal at once, if the print is accurately drawn, the corresponding British measurement. Usually, however, the prints furnished are only roughly to scale, with the dimensions stated in millimetres, so that it is necessary to reduce them to feet and inches by means of the rule which has been mentioned, or tables may be compiled or purchased to show at a glance the value of 1–1000 millimetres to the nearest sixty-fourth of an inch.

*Arrangement of Elevations and Plans.*—The paper having been tightly stretched on the board, the overall dimensions of the work in hand is noted, so that the views may be well set out. The side view will be the full length of the chassis, including any forward and rear overhang of the springs, and if a landaulette or cabriolet the extent of the head when down. To this will be added, with a clearance between the views of, say, 1 in., the half or full width of the body at its widest point (usually the steps or wings). The majority of cars are seldom more than 7 ft. high overall when mounted on the chassis, although 6 ins. or

7 ins. may be required in addition for a luggage rail, or 15 ins. to 20 ins. if the travel of the opening of the cant rail is to be shown. Plan views will be the same depth as the end views are wide.

The arrangement of a detailed scale drawing will be—side elevation at the top in the centre, back view on right, front view on the left, with the plan below the side view, so that the various views can be projected from one another.

An example will now be taken from which it will be gathered how the work is done, and necessarily much will be learnt in connection with motor body design. It is taken for granted that the reader has a knowledge of the elementary principles of plane and solid geometry.

*Drawing a Flush-sided Phaeton.*—A flush-sided phaeton will be taken as the example, and the chassis on which it is to be mounted has the following dimensions. It is proposed to draw the side, half-back, half-front, and full plan views :—

| | Millimetres. | ft. | ins. |
|---|---|---|---|
| Height of chassis side member from the ground (in the straight) | 610 | 2 | 0 |
| Dashboard (all dashboard measurements are taken from the body side of the dashboard) to back of hind cross member of the chassis | 2495 | 8 | $2\frac{1}{4}$ |
| Thickness of dashboard | 15 | 0 | $0\frac{5}{8}$ |
| Height of dashboard | 660 | 2 | 2 |
| Rise of frame on side at rear | 60 | 0 | $2\frac{3}{8}$ |
| Radius of curved profile (top centre from hind axle centre) | 381 | 1 | 3 |
| ,, ,, ,, (radius bottom centre) | 622 | 2 | $0\frac{1}{2}$ |
| ,, ,, ,, (from hind axle centre) | 41 | 0 | $1\frac{5}{8}$ |
| ,, ,, ,, (radius from above) | 292 | 0 | $11\frac{1}{2}$ |
| Centre of front wheel from dashboard | 835 | 2 | $8\frac{7}{8}$ |
| Height of wheels | 880 | 2 | $10\frac{5}{8}$ |
| Tyre section | 120 | 0 | $4\frac{3}{4}$ |
| Wheelbase (distance between axle centres) | 3164 | 10 | $4\frac{5}{8}$ |
| Width of frame | 910 | 2 | $11\frac{7}{8}$ |
| Distance from dashboard to intersection of steering wheel and column axes | 603 | 1 | $11\frac{3}{4}$ |
| Diameter of steering wheel | 406 | 1 | 4 |
| Height from top of frame to centre line of steering wheel at lowest point | 635 | 2 | 1 |
| Wheel track (distance between vertical axes of hind wheels) | 1435 | 4 | $8\frac{1}{2}$ |

| | Millimetres. | ft. ins. |
|---|---|---|
| Dashboard to quadrant centre | 546 | 1 $9\frac{1}{2}$ |
| Height of brake lever | 686 | 2 3 |
| Brake lever stands out at top from the side of the chassis | 190 | 0 $7\frac{1}{2}$ |
| Height of bonnet | 533 | 1 9 |
| Angle of steering column | 45 degrees | |
| Extent of travel of brake lever | 5 degrees inwards and 25 degrees outwards | |
| Position of differential casing | Level with top of straight portion of chassis | |
| Petrol tank | At rear below top of frame | |

Further measurements are mentioned in the description of the drawing which follows.

*Fixing the Paper.*—It being assumed that a $1\frac{1}{2}$-in. scale drawing is being made, the largest sized board is taken and on it an imperial sheet of Whatman's paper is pinned, taking care to stretch the paper as tightly and as evenly as possible. Some prefer to strain the paper on while wet. This is done by gumming round the edge of the board and damping the sheet all over, and laying it down with the wet side uppermost, using pins to retain the edges while drying. This makes a beautifully smooth surface to work upon when dry, but it entails a slight delay, although this may be avoided by having reserve boards and papers already stretched in position. The paper is then removed, when the drawing is finished, by running a sharp knife inside the gummed edge.

Taking the ordinary method, however, it is a slight advantage if two sheets be pinned on at once, so that should there be any inequalities in the surface of the board the lower sheet protects the pen or pencil from lodging in a groove, also when the ink eraser is used no dirt is transferred to the back of the working sheet of paper.

*Spacing out.*—To space the drawing out well, the overall dimensions of each view must be approximately known. The side view will be the extreme length of the chassis, which is generally shown on the blue print, while the end views will be

half the extreme width of the chassis. As the track is 4 ft. 8½ ins., a measurement of 5 ft. may be safely reckoned on, and as the body is only to seat two comfortably on each seat this will not be exceeded, that is to say, the body will not be wider than over the wings or step board, and it may be mentioned in passing that it never should be.

The overall length will be reckoned at 14 ft., and the height, showing the cape cart hood up, at 7 ft., and the plan view 5 ft.

The paper is divided horizontally into four equal portions, by a central line both horizontally and vertically by the lines AB and CD (see folded diagram, Fig. 17, which has been reduced from the 1½-in. scale drawing).

AB will form the ground line of the three elevations, while CD will be the centre line, each side of which will be measured half the overall length, namely, 7 ft. The space below AB may be divided again horizontally by the line EF, which will form the centre line of the plan view. If only half the plan were shown, then the line AB would be dropped accordingly, and if full end views were shown it would probably entail some of the detail overlapping the side view, which is not considered objectionable, unless the drawing is for special purposes. It is advisable to work on paper as small as possible consistent with clearness, as errors in projection are less likely to creep in, besides providing a drawing easier to handle.

On the ground line AB the draughtsman now proceeds to copy the details given on the blue print, and often it means a transposing of scales from $\frac{1}{10}$ to $\frac{1}{12}$ or $\frac{1}{8}$. The height of the chassis above the ground is noted, and a horizontal line drawn in with the T-square 24 ins. above AB, right across the paper. On the blue print is struck a central vertical line corresponding to CD, and the distance measured with a metric rule or an English one, in any case multiplying by ten, from this central line to the front wheel centre. This is found to be 5 ft. 11½ ins., and measured off with 1½-in. scale, a vertical line GH being drawn, on which the circle representing the front wheel is drawn. This is done by taking a radius half 2 ft. $10\frac{5}{8}$ ins. = 1 ft. $5\frac{5}{16}$ ins.,—and marking it off on the line GH, with the point of the compass at its junction with the line AB. This gives point I, on which, without altering the

compasses except to transfer the point from G to I, the circle of the front wheel is drawn. The wheel diameter may be more quickly halved by taking off 2 ft. $10\frac{5}{8}$ ins. on the $\frac{3}{4}$-in. scale, and leads to less mistakes. To the right of GH may then be marked off the wheel base, 10 ft. $4\frac{5}{8}$ ins., another vertical line drawn, JK, on which the hind wheel circle is similarly described.

To draw in the rise of the side member of the chassis (this is of less importance as to its exactness in a scale drawing than in a full-size drawing, as the curve obtained is of no practical use for marking out the stuff), distances $1\frac{5}{8}$ ins. and 15 ins. are each measured to the left of JK, and vertical lines, LM and NO, drawn in. The point of the compass is then placed at the intersection of line NO with the top of the chassis, and a radius of $24\frac{1}{2}$ ins. struck off, the point of the compass being transferred to this mark, and the arc P struck. The chassis rising $2\frac{3}{8}$ ins., this distance is indicated by a line, Q, drawn parallel to the top of the chassis. Where this cuts line LM, a distance of $11\frac{1}{2}$ ins. is marked off below on LM, and the arc R, with a radius of $11\frac{1}{2}$ ins., drawn in. If carefully done the two arcs, P and R, and the straight lines of the chassis at its two heights will run neatly into one another. The dashboard is drawn in by marking off $32\frac{7}{8}$ ins. to the right of the front wheel centre, and the thickness by a line $\frac{5}{8}$ in. to the left of it. Remembering that all dashboard measurements are taken from one side of it (preferably the back) the length of the chassis is marked off, 8 ft. $2\frac{1}{4}$ ins., and the vertical line S drawn in. The steering wheel is the next consideration. Mark off $7\frac{1}{4}$ ins. on the dashboard, above the line of the top of the chassis, and through that point draw a line at an angle of 45°, using the set-square resting on the edge of the T-square held firmly against the left-hand side of the drawing board. For angles otherwise than 45°, 60°, and 30° use the protractor. The line so drawn is the axis of the steering column. To the right of the dashboard draw another vertical line T, 1 ft. $11\frac{1}{8}$ ins. from the dashboard, and where this cuts the line just drawn is the intersection with the steering wheel axis. Draw a line each side of this at right angles by means of set squares, or with the compasses, using a simple geometric problem, measuring off 8 ins. to right and left. The steering wheel being $1\frac{1}{4}$ ins. thick, allow $\frac{5}{8}$ in. either side of the central line, and round

in the ends. The position of the steering column may be given in other ways, sometimes the length from the dashboard to the back of the wheel being given, and height above the top of the chassis. The drawing in of the thickness of the steering column is merely a matter of finish, being of no practical use in designing the body, a remark which applies to several other features of the chassis. Allow 9 ins. below the lowest point of the steering-wheel, and draw in a horizontal line, this will be the top of the cushion; and again another one 6 ins. below, which will indicate the height of the seat board in front.

Draw a vertical line, U, immediately at the back of the steering wheel. This will be the front of the driving seat, and the right-hand side of the forward door, providing that further considerations do not indicate that it will be necessary to bring this line more forward so as to get a proper entrance to the hind seats.

*The Main Dimensions.*—The hind wing should now be drawn in with a minimum clearance of 5 ins., and temporarily as an arc concentric to the hind tyre with a 5-in. greater radius. Now proceed to apportion out the seating, leg room, and back-door gangway. A measurement of $20\frac{1}{2}$ ins. to the right of the line U will give a comfortable driving seat width, the line S (the back of the chassis) should be the limit of the body, and in order to get as ideal a body as possible, it will be endeavoured to use this point from which to work forwards to the dashboard. Allow 25 ins. vertically for the depth of the body side overall on the square, and draw in the horizontal line VW, and then two more, $5\frac{1}{4}$ ins. and $6\frac{1}{4}$ ins. respectively, above VW, which will represent the rise of the two seat elbows. Where the vertical line touching the back of the driving seats cuts the rise of the front elbow, measure to the right $4\frac{3}{4}$ ins., being a suitable "sail" or throw-out for the driving seat back panel, and draw in a straight line X as shown. Measured on the slant this gives a measurement of about 24 ins., which is ample to give support to the back. Now drop the line of the seat 2 ins. at the back, and an angle slightly greater than a right angle will be formed, which will remain more or less about the same, so that if the seat is inclined differently the back of the seat should follow with it.

Show below the seat line the thickness of the $\frac{1}{2}$-in. seat board.

The curve representing the rise of the elbow may now be sketched in, and similarly the one at the rear.

*Freehand Drawing.*—Here comes the first little piece of freehand drawing, and the draughtsman should firmly resist the temptation to find a pattern that will fit the desired curve, and draw in the required line unaided. Such a course leads to more originality in design, besides helping him to acquire an ability which is of the highest possible service to the accomplished draughtsman. It will be noticed that an extra inch is given to the rise of the hind seat elbow, as this prevents any tendency for the hind seat to look less important than the front, which would be the case if both were made the same height. As the hind seat elbow is slightly higher, it may also be allowed to rise from the straight somewhat sooner.

As the driving seat sails $4\frac{3}{4}$ ins., the rear one must turn under at least the same amount for the same depth, and, as the line drops right to the chassis, $6\frac{1}{4}$ ins. will not be too much. This distance is then marked off from the square line S, and a gentle rotund curve drawn in, taking care that there is no tendency for the line to run in at the top, and that the tendency for fulness is in the lower part of the line. The back line of the driving seat may also be a rotund curve, but as the greater part of it is hidden, the design as shown allows of a cheaper job. The rise of the elbows and the shape given to turnunders is naturally much a matter of taste, and throughout this book body styles will tend to err on the side of restraint rather than exaggeration.

*Plotting the Doorway.*—The levels of the front seat are now transferred to the rear, and another $20\frac{1}{4}$-in. seat board drawn in with the back edge touching the turnunder line. Between the two seats there is now left 20 ins. leg room, measuring horizontally, which is quite sufficient for comfort, as there are no extra seats to be adopted, and there will be no cabinet or other impedimenta behind the driving seat. The door is now plotted, and an endeavour will be made to obtain a 22-in. doorway. If this measurement is taken immediately forward of the front of the hind seat an encroachment will be made on to the space occupied by the driving seat, and although it would not be to a serious extent, matters will be compromised by allowing the hind seat to project an inch in front

of the back line of the door. The two vertical lines of the 22-in. doorway may then be drawn in.

Before the door can be finally settled a $1\frac{3}{4}$-in. bottom runner is drawn in. To this is added the extra thickness of the door bottom side, which may be framed in separately or left on the main runners, and usually the former plan is more economical. The bottom of the door may be lower still if it is a "cut through" doorway, in which instance the door bottom, when closed, is by the side of and not above the bottom side, or rocker as it is then called.

Allowing $2\frac{1}{2}$ ins. overall will give the bottom line of both doors. The bottom corners may be rounded off, but this is much a matter of taste, although it will assist sometimes in getting a proper clearance for the wing, and is a shape which is less liable to tear the clothing.

Without rounding in these corners it is found that the line temporarily drawn in for the hind wing crosses part of the lower right-hand corner of the door. This may be done away with by sketching in the curve of the wing so that it turns in more sharply towards the tyre, the only precaution necessary being to see that the minimum clearance of 5 ins. is preserved vertically at all points from the tyre. This can be easily done in this instance, and the wing is drawn in as shown, and therefore the hind door may be left as drawn in, also the wing being closer to the wheel it is a better mud intercepter.

*Designing the Scuttle-dash.*—The next operation is to draw in the lines of the scuttle dashboard. Draw in the top of the bonnet 21 ins. above the top of the chassis, and mark off 26 ins. as representing the height of the dashboard. The front backward inclined line of the scuttle should not start at a point too far above the top of the bonnet, but at the same time it is more important that the occupants of the driving seat are adequately protected. In future designs of chassis the lines of the bonnet will probably receive more study at the hands of the motor manufacturer, so that harmony between the bonnet and body may be better preserved. In this instance a start will be made from the top of the dashboard, and continued back behind the dashboard 8 ins. (measuring horizontally), giving a rise of $5\frac{1}{2}$ ins., and then running the line from the top of the scuttle down into the line of the top of the body side in a gentle

curve as shown. The higher the steering wheel, the higher the scuttle should be, and it would be an advantage if a proper control of the steering could be obtained by having the wheel itself nearer the dashboard, so that merely inclining it at a greater angle does not necessarily mean that the distance back to the driving seat is increased and compactness thereby lost, as pointed out in the chapter on the steering gear. Starting from the front of the driving seat, a doorway of 21 ins. is marked off to the left, and the top of the front line of the door rounded in, since the contour of the body curving inwards would mean that if the line were kept straight up an awkwardly shaped piece of door would result, in fact it would be a sharply pointed piece dangerous to entrants, and very liable to be broken off.

*Wings and Steps.*—To draw in the step boards, measure the distance from the ground (do not allow for a curb, as this is not always present in the country lane) to the bottom of the door and halve it and allow an extra inch for the first step; this will be the top line of the long side step, or running board. A line $1\frac{1}{4}$ ins. below will give the thickness of the step. Finish off the hind wing by running it down to the step, taking care to make it an angle of not less than a right angle for appearance' sake, while the tail end may be continued round with a concentric circle to the level of the centre of the wheel.

The front wings will run round to within 6 ins. or 7 ins. of the level of the centre of the wheel, and the concentric arc may be run into a return curve, so that it just meets the top of the step at a point below the dashboard. This will not always be the case, and will depend on the length of the bonnet and its relationship with the wheel, and so on, while further details on wing design may be obtained by consulting the chapter devoted to "weather protection." The wing flanges may also be added (not shown in the drawing), and it is a neat arrangement to make the front flange meet the step thickness, rather than let the top of the wing come level with the bottom of the step.

*The Half Back View.*—Attention may now be directed towards the half back view. Project the height of the chassis frame at the rear, also the height of the back panel, height of hind wheel, and wing, height of hind seat in front, and level of the top of the cushion

in front. Draw a vertical line about half an inch (full size) from the edge of the paper, which will represent the half line of the back view. From this line measure to the left on the ground line, 2 ft. $4\frac{1}{4}$ ins., as representing half the track, and to right and left half the width of the tyre, namely $2\frac{3}{8}$ ins., then draw in a semicircle top and bottom, and the end view of the wheel is obtained. Measure off half the width of the frame, $17\frac{15}{16}$ ins., and draw downward a short vertical line. The width at the front of the hind seat must now be decided. A medium-sized brougham measures 3 ft. 8 ins. between the hind standing pillars, which usually correspond to the front of the seat, which dimension will be increased on the top of the cushion, according to the shape of the inside face of the pillar, which will be largely influenced by the turnunder; a large brougham will be about 3 ft. 10 ins. on the seat. This measurement may then be looked upon as ample for the comfort of two passengers even in a fast-moving car.

*Deciding the Width of the Hind Seat.*—In a flush-sided phaeton, such as is under consideration, it will be noticed that the hind wheel crosses the horizontal plane of the seat, and if 3 ft. 10 ins. be measured on the line on the half back view, which has been projected from the front of the seat, it will be found to leave a very small margin between the side of the seat and the wheel, even without allowing for the extra thickness of framing and panel, and the up-and-down motion and side sway of the body. As a precaution it will be advisable to show the position of the wheel at its point of maximum deviation from the unloaded position. It will be presumed that the body is capable of moving downwards 5 ins. vertically, and $1\frac{3}{8}$ ins. laterally; this may be expressed by copying the end view of the wheel at a position 5 ins. higher and $1\frac{3}{8}$ ins. to the right. This done, the turnunder and width of the seat may now be safely planned out.

An allowance of 3 ft. 10 ins., with $1\frac{1}{2}$ ins. only allowed for framing, brings the body right on to the tyre, so this is clearly impossible, besides preventing any increase in the width above to allow for the sail of the body. So it will be advisable to see what measurement can be obtained without specially recessing the body panel. To do this, trace the back line of the body in the side elevation together with the square line which meets it at the top, also the top line of

the chassis. Turn the tracing paper over, laying the line formed by the top of the frame on the line projected in the half-back, and slide it along until the curve clears the tyre at its maximum deviation, say ½ in., transfer this line to the paper (by simply drawing over it with the pencil), and a suitable line will be obtained to work on. It is not, however, essential that the turnunder at the back should be the same as that at the side; as a matter of fact it is generally less, but it should in any case harmonize. The line Y as drawn in means that the bottom framing of the body need not be unduly heavy, but it seriously curtails the space available for the passengers' legs.

The point which must remain is where the tyre is nearly touching the panel at *a*, and that portion of the line above and below may be shaped as required, having due regard to the corner panelling of the body working into a shapely surface. If the line is brought further out at the bottom as indicated by line *b*, a wider seat may be obtained, and increased comfort for the passengers. Sketching in the line *b* a further half-inch each side is obtained at the seat, and 1¼ ins. each side for the feet, and drawing in a line parallel 1½ ins. inside represents the inside line of the framing.

On the line indicating the top of the cushion it will be found that it measures 1 ft. 11¼ ins. from the half-line to the inside of the framing, which being doubled means that the cushion will be 3 ft. 10½ ins. at the top in front, which is ample for two, and therefore the line *b* will be suitable for the purpose. It often happens, however, that the client wants comfort for three, which means a minimum of 4 ft. inside the framing, and springs often upset the whole calculation by encroaching on the space immediately beneath. However, the springs in this case are the ordinary half elliptics, and two only will be seated. For the sake of completeness, the wing may be drawn in and the position of the step and its stay shown. The wing is placed centrally over the wheel, and made ten inches wide, and the step will agree with the width of the wing.

*The Full Plan.*—It will now be advisable to proceed with the plan before inserting more detail in the other views, as often the plan will suggest modifications being made in the elevations. The full plan is drawn to give a better idea of the seating arrangement to the customer, who is not always sufficiently technical to

appreciate a half view only. For a similar reason full end views are often adopted.

On each side of the line EF draw half the width of the chassis, and inside this the width of the side members 57 mm. or $2\frac{1}{4}$ ins., lines *q* and *r* respectively. This inner line *r* decides to a great degree the inside line of the bottom runner, and therefore its width, the outside line being already represented at the widest part of the body by line *b* in the half back view.

Project vertically lines downward from the side elevation at the wheel centres and extremities, ends of wings, dashboard, front and back of seats, top of back panel of both seats, door gangways, back of frame, and other points. On the line *c* projected from the front of the hind seat, take off with the dividers the seat width and that of the body at the top (points *d* and *e*), and width on bottom (point *n*). The seat line has to run round to *f*, and the top line of body to *g*, and *n* to *o*. Whichever line is drawn first, the others must harmonize with one another, and the fulness of the corner is much a matter of taste, but if the corner is made too slow it will not allow the passenger to sit snugly with his shoulders well supported.

Draw a horizontal line through *e* until it cuts *g* at *h*, through *h* draw a line at 45°, and as a guide to a suitably shaped corner measure on the line just drawn $18\frac{1}{2}$ ins. from *h*, giving point *i*, and draw in an arc *p* of not greater than 11 ins. radius. With this arc as a guide draw in the curved line from *e* to *g*, remembering that the line must come into the straight at least 6 ins. before it arrives at the centre line, otherwise it will tend to form a peak in the back panel. The radius of the corner of the top line of the body usually runs in medium-sized bodies about 9 ins., and at the seat 6 ins. Smaller bodies should have sharper corners, so as not to look too tubby. The bottom line of the body or outside of the runner may now be obtained by the following geometric procedure.

*Setting out the Hind Corners.*—Take any point *k* on line *c*, and join *kh* and *kl*, *l* being the point of intersection of the body bottom width; produce *n* until it cuts line S at *m*. Take any point *j* on the line EF, and join *mj* and *hj*. Take any number of points in curve of body, say four, numbering them as shown. Corresponding points may now be obtained on the body bottom line, through which the line

*no* is drawn, and the more points taken the more accurate the resulting line. Produce point 1 horizontally to the right until it touches *hj*, at this point drop a short vertical line to *mj*, and from this point produce a horizontal line to the left. From point 1 again produce upwards a vertical line touching *kh*, then horizontally to the left till it touches *kl*, and vertically down again until it touches the horizontal line produced from *mj*. This is point 1′ on the line *no*. The other points are similarly projected, and then through them the bottom line is carefully sketched. This trouble is not often taken in motor body shops, but if adopted it takes up but little time, and well repays the slightly extra trouble taken by the beauty of the panel surface produced, if it is intelligently carried out. The seat line *df* may be similarly plotted.

*Enclosing the Levers.*—The plan will be largely influenced according to whether one or both levers are enclosed. If both are enclosed the greatest width overall the outer or brake lever, plus a reasonable clearance for the grip of the hand (say, $2\frac{1}{2}$ ins. from the centre of the brake handle), will decide the minimum width inside the body throughout the path travelled by the lever. If one lever is outside, and the other inside, then the door must come neatly between them, and so far very few blue prints give sufficient information so that this may be done with confidence, without reference to the actual chassis.

Draw in the brake lever and its travel in the side elevation, by making the rolling centre $21\frac{1}{2}$ ins. from the dashboard, and 1 in. below the top of the chassis. With the compass draw in an arc of 27 ins. radius, and draw a vertical line through the rolling centre. With the protractor mark in an angle of 25° and 50° to the right and left respectively, and with these as centre lines show a lever 1 in. wide. Project the limits of travel to the plan, and draw in also the quadrant by means of a rectangle $4\frac{1}{2}$ ins. deep and $7\frac{3}{4}$ ins. wide, abutting on to the outside of the chassis, and $2\frac{3}{4}$ ins. to the right of the lever working centre.

The brake lever stands out $7\frac{1}{2}$ ins. to the centre of the handle from the side of the chassis; adding to this half the width of the chassis, a measurement of $25\frac{7}{16}$ ins. is obtained. If the off-side door is fixed, because entry on that side to the driving seat is awkward, it may be, say, $\frac{3}{4}$ in. in thickness, but if it is to be hinged, at least

another $\frac{3}{4}$ in. will be added. Presuming, however, that it is fixed, and allowing $2\frac{1}{2}$ ins. as before mentioned, as hand clearance, a half-width over all the body of $17\frac{15}{16} + 7\frac{1}{2} + 2\frac{1}{2} + \frac{3}{4}$ ins., is obtained, namely, $28\frac{11}{16}$ ins., as the minimum width of the body where the lever works. Project the height of the lever from the side to the end elevation, and mark on it this measurement, and it will be found that if both levers are to be enclosed the body will have to be $2\frac{3}{4}$ ins. wider a side at the front. This will not make an artistic body; it also means greater weight of timbers in the bottom framing, but on the other hand, greater protection for the passengers. If the width of the hind seat be increased, and the body paddle-boxed at the hind wheels, so as to keep the outside lines of the body more parallel, this entails what is obviously a clumsy method of getting out of the difficulty, although it is often necessary with the present types of chassis.

The most suitable compromise will be to have a fixed door running between the levers, and for this full details regarding the movement of the change-speed lever must be known.

The change-speed lever stands out $\frac{7}{8}$ in. from the chassis when in first speed, is 24 ins. long and 1 in. wide, works from a centre 1 in. above the brake lever, and moves laterally $3\frac{3}{8}$ ins. to engage the third speed, while its limit of movement is 10° backward, and 15° forward. Mark out these positions on the elevation and plan.

More detail regarding the quadrant will now be necessary, and it will be convenient to draw in the levers in a small separate end view, as shown between the side and half back views. On examining this sketch it will be found that the centre line *s* of a door to come between the levers measures, as the half-width overall, 1 ft. $11\frac{3}{8}$ ins., measuring from centre line *t*, which length, transferred to the height of the speed lever projected on the half back, means that the body will be, allowing $\frac{3}{4}$ in. for the substance of the door, $1\frac{1}{4}$ ins. narrower a side at the front than at the rear, which can be easily controlled by the line taken up by the side sweep of the body, without interfering with the comfortable width of the driving seat, as the lever travel is all in front of this seat. The rake given to the levers also decides the turnunder of the body at this point, but they may be slightly set backwards or

forwards if necessary, but it is not essential that the contour of the off side door should be exactly reproduced on the near side, although the carriage builder will necessarily prefer to have it so.

The designers of artistic motor bodies naturally look forward to the day when speed levers will be centrally placed, and all brake control confined to pedals, which is not by any means an engineering impossibility, but naturally motor manufacturers are shy of presenting drastic innovations on their chassis, as they have to take into consideration whether they will be appreciated by the motorist.

Having made a careful drawing of the position of the speed lever in both its positions, and also brake lever, the section of the off side door is drawn in as shown in the small sketch. The width of the body at *e* having already been decided, and the limit of width having now been ascertained from the position between the levers, the outside line of the body from *e* to *u* may be sketched in, and so long as it is slightly fuller than a straight line the style of the body will be maintained. This line runs round to the dashboard, while it also meets the curve *v*, which runs round to the bottom bearing of the wind shield. The outside of the bottom side or runner is already known at *n*, and in order to draw it in forward, and maintain about the same turn-under (it may be gradually decreased if necessary), the compasses are set to the distance *en*, and short arcs marked off from the line *eu*, so that a line parallel to *eu* is obtained, which is finally run into the dashboard line in front. It is now seen that the position of the quadrant will necessitate cutting away most of the bottom runner on the off side.

The driving seat line may be obtained by drawing in a small section as shown in the doorway to the back seats. The turnunder on line U is already shown in plan. Draw two vertical lines the distance of the turnunder apart, and also to the left represent the centre line of the car, and the width of the chassis. The horizontal line already drawn in, in the elevation, will show the half-length of the seat overall in front, which is then transferred to the plan on line U, and the curve of the seat drawn in with about a 6-in. radius at the corner. The top line of the seat will correspond, allowing

it, in the first instance, to run into the outside line of the side of the body.

*Finishing off the Elevations.*—In the back view the line of the horseshoe moulding may be drawn in, letting the half-width of the shoe be about the same as the space left on each side. The lower part of the shoe should run, as near as possible, parallel to the side turnunder, and run in neatly into the top line. Mouldings $\frac{7}{8}$ in. wide can then be drawn on the elevation.

*The Half Front View.*—The half front view is not of much consequence in an open body, but in limousines and landaulettes there are front lights to design. However, the lines of the dash, the top line of the scuttle, and the greatest width of the body may be shown, also the front wheels in position. The point $x$, at which the scuttle line runs into the straight, is obtained by projecting from the side elevation into the plan, measuring the width at that point and transferring to the half front view.

*Setting out the Cape Cart Hood.*—The cape cart hood may be shown by drawing in a horizontal line 3 ft. 10 ins. off the front of the seat board. This is the head room allowance, but this should be decreased if the cushion will be less than 6 ins. thick, or if the seat slopes more than shown. Allow a drop of 8 ins. in front and 3 ins. at the rear with a sail of $1\frac{3}{4}$ ins. measured from a line $1\frac{1}{4}$ in. beyond the line S, which allows for the thickness of the trimming roll. The position of the sticks will differ according to the number used, and the particular mechanism adopted. For the sake of simplicity three upright sticks only will be used each side.

Point $y$ is $3\frac{1}{4}$ ins. to the right of the door shut line, and $2\frac{1}{4}$ ins. above the top line of the body. In this position it is well clear of the gangway, and the radius from $y$ to $z$ clears the back rest well so that the hood can be properly lowered.

The centre line of the corner stick runs up to the line of sail at the rear of the hood, and its junction with the line $yz$ will depend on the exact shape of the type of cape hood ironwork purchased, for it is seldom that the carriage builder now makes his own, in which case it would entail a drawing being got out for the smith. The front vertical stick centre is 8 ins. to the right of the front door shut, which is again well out of the gangway, and leaves 38 ins. spread between it and the next stick, which is

not too much without setting up undue sagging of the hood. The front horizontal sliding stick is brought well forward of the wind screen some $7\frac{1}{2}$ ins., which decides the front peak of the hood.

The position of the wings, steps, and wheels is shown in the plan, and the swing of the doors is obtained by projecting the hinge line into the plan, and measuring out from the surface of the body the distance out of the pin of the hinge. This is the centre required, while the radius will be the width of the door. From the shape of the turnunder it will be expedient to use an outrigger hinge at the bottom.

In the drawing, most of the constructional lines have been left in so as to assist the student in following the various steps taken. Further detail would consist of showing the framing, and, if required by the customer, the general arrangement of the trimming in the plan. The position of the elbow rolls and cushions is shown in the elevation, and with the cape hood the position of the hind body prop is set out so as to show how the fall of the hood is predetermined, while the same piece of ironwork projected into the plan shows how much it has to stand out from the body so as to get a fixing, and give sufficient width to take a stick, which is greater than the full width of the body.

# CHAPTER VII

## *MOTOR BODY MAKING*

The construction of motor bodies is a craft which has been directly evolved from the building of horsed carriages, but although many of the principles adopted are the same, yet the mounting of the body on a chassis has simplified matters in one direction, in that no locking forecarriage has to be allowed for, while in the other the larger number of requirements which have to be fulfilled have necessarily created several differences in the setting out of the framework and panelling.

The body maker is a wood worker whose employment differs materially from the house joiner and carpenter, because on the whole he has to work in harder woods, the structure dealt with is more complex, necessitating a larger tool kit, and greater skill and accuracy of fitting is absolutely essential.

*The Question of Light Construction.*—English ash, being strong and elastic, is the most suitable timber with which to make the several parts of the framework for cars used in temperate climates, although the American variety, which is less strong, may be safely utilized for parts where no great strain takes place. Seeing that the body is directly supported on the chassis, one would naturally suppose that some of the main framework of the body would be lighter than in a brougham where the body has to maintain its correct shape independently, and has to be stiffened by a large edge plate on either side.

With a front standing pillar there must be sufficient size at the top in order that the tenon formed in the end is strong enough to make a serviceable joint with the mortice in the cant rail. At the centre of the same pillar the width on the inside face must be sufficient to allow for the glass frame and the necessary clearances and allowance each side of the run, while at the foot there must be

again enough left for fixing to the bottom side and rocker side, although on many occasions a great deal of extra material has to be used in order to give a certain shape to the toe of the pillar, apart from constructional needs. Such a pillar, seeing the influences which govern its size, will differ little whether forming part of a limousine or horsed brougham.

With the hind standing pillar, this usually has to withstand the strain of the door hanging, but less material is cut away now that butt instead of concealed hinges are used; still the elbow, seat, and lower framing is, as a rule, longer, and therefore needs practically as stout a fixing place as if these parts were shorter and not directly supported.

*Why Stout Timbers are required.*—The weight of pillar timber is, however, usually greater than in the horse carriage, simply because the chassis is seldom ideally designed to carry a body such as is required by the motorist.

A fashionable horsed brougham has, say, a 2-in. turnunder, meaning that the width overall on the bottom at the door is 4 ins. less than at the elbow; here it is possible to shape the body to give the maximum of comfort, and then design an undercarriage to suit it. With the motor car, however, the chassis sizes are predetermined and a 6-in. turnunder, meaning 12 ins. less overall at the bottom, is quite a common occurrence. This larger turnunder would not necessarily mean a heavier framework, only in bodies which are provided with drop lights the path of travel of the glass frame must necessarily be a straight one, or even if it is slightly curved this cannot save much timber, as the same glass frame has to occupy the run above the elbow as well as all positions below it. It may therefore be deduced that a great deal of weight can be saved in any type of body if it has no drop glass frames, as the inside face of the pillar can be parallel to the outer one.

The elbow in a motor body has usually to stand the strain of a greater weight of head work in a landaulette; for that reason the elbows, corner pillars, and hind cross-framing cannot be any lighter than in a large horsed landau. The hoopsticks which carry the roof-boards have in many instances a greater width to bridge over, and heavier luggage to carry, so that the presence of a chassis does not permit of any diminution in their substance.

*Saving Weight in Seat Construction.*—Perhaps the chief item where weight can be saved is in the seat bottom side. This, in a horse carriage, has to be strong enough to take the fixing for the pump handle to which the hind carriage is attached, and deep enough to take the edge plate on its inner face. In a motor car the main seat is directly supported by the rocker side, so that in a limousine, or open body, the seat framing, an inch in thickness, does duty also as a thick seat bottom side, a practice which can be safely adopted in landaulettes also, but so far this style of framing appears to be confined to taxicabs.

Weight in excess of constructional requirements is present in the front top rail of a closed body. Here the bottom line has to conform to a suitable groove to hold the glass frame when right up, and the top line of the rail follows the rise given to the roof. Now it is an established practice that the top line of the lights shall run round the sides and front of the body so as to be on the same level; this means in the case of either a side or front light that the extra depth of a door top has to be added to the substance of the rail. It would no doubt cost more to frame and panel this upper framework, or failing this, it would be better to use simply the amount of substance required without regard to lining up.

Additional weight is often caused by the adherence of a designer to old rules, and one of these is that a glass must be completely hidden when it is on the glass rest. In a front pillar, with a 6-in. or 7-in. turnunder, this means a large bulk of stuff left on the inside in order to get a straight drop for the glass, although a lighter method of construction is sometimes used by framing and panelling as suggested above with the upper framework of lights.

*The Weight Factor as directly influenced by the Chassis.*—The flange of the chassis on which the bottom of the body rests is about 2 ins. wide. If the bottom framework could be made that width only, then many pounds could be saved in weight. Usually, however, this 2 ins. is but a mere ledge or side bearing for a bottom runner some six or more inches wide, made necessary by the width of seat demanded, and confining turnunder within reasonable limits so as not to unduly cramp the legs of the passengers. If extra width were put in the chassis, all cross members, shafts and axles would have to be longer, which in the end would probably mean a

greater weight than is already entailed in the present method of body building. This bottom framing need only be wide, any great thickness apart from a suitable allowance to take the foot of the pillars and the rebates for the floor boards is all that is necessary, although even this consideration may be disregarded by placing the floor boards on top of the bottom runner instead of letting them in.

Attention has also been directed in the chapter on drawing to the extra dimensions of timbers necessary owing to the placing of the control levers and springs, so that, summing it all up, there is little chance of the framing of a motor body, although it is well supported, being made lighter than a horse carriage of even similar capacity, unless comfort and convenience are considerably curtailed.

*Pattern Making.*—The first operation in building a body is to make the patterns. These are made in pine or birch, while mahogany is useful if they are to be retained for extended further service. The piece of timber is laid under the full size drawing, and the outline of the desired pillar or rail pricked through with the scriber or other tool. On the pattern is marked the thickness of the stuff, and the number of identical pieces required. The standing and door pillars are also marked out from the turnunder pattern, which is their sectional shape, while pieces such as the elbow, fence rail, and other parts of the side framing are marked out as if flat, and in a suitable substance of plank corresponding to their greatest thickness, the rail being afterwards shaped off by means of the hollow side sweep.

*Marking out the Stuff.*—In a large shop, after the patterns have been made, the body maker does not see the framing again until it is all planed and grooved, with joints formed, holes bored, and other processes completed, so that he has little to do but to fit and fix the various members together. In the majority of shops, however, the body maker is responsible for marking out the stuff on the plank, and in so doing he can show no little skill, in wasting as little of the timber as possible, as well as utilizing the natural direction of the grain of the wood, in order to get the utmost strength for the individual pieces. With his patterns before him he will separate them into sets requiring the same thickness of plank, and arrange them on the timber so that outlines lie together as closely as possible, being careful to dodge all knots and other imperfections,

and it is a simple precaution to turn the plank over and examine it before marking out on the other side. The body maker takes for granted that the plank he is allowed to use is seasoned, otherwise the resulting framework will not only shrink, even before it leaves the factory, but a weaker structure will result, and blemishes will be set up in the paint work. In marking out, it is useful to look at the end of the plank, so that its former position in the log may be ascertained, because timber tends to shrink towards the bark, and away from the heart, and in marking out a door pillar it is an advantage, if the timber is to shrink ever so slightly after the body is in service, that it should tend to bring the pillar in at the top and bottom, which means, that under the influence of the holding of a well fitting lock in the centre, the door will close tightly along its whole depth. If, however, the pillar casts in the opposite direction there is nothing to counteract the defect.

In marking out due allowance has to be made for, say, the extra length of a tenon or lap, and the greater substance a pillar or rail will develop by reason of a bevel being present such as is exhibited on the cant board.

*Wood-working Machinery.*—Where there is a sawmill the band saw cuts out the shape of the pieces from the plank, an experienced sawyer working well up to the outline marked out, so that subsequent operations are reduced to a minimum. Where two surfaces are not at a right angle, the table of the saw can be tilted to suit these conditions. The circular saw is useful for straight work, a face side can be given on the overhand planing machine, while it can be dressed to gauge by running the timber under in the thicknesser. The spindle machine dresses up the stuff on the sweep, while boring and mortising is done on various types of wood-working machinery fitted with a variety of drills. By means of special knives fitted to the spindle machine, mouldings and other types of raised work and depressions can be formed, according to the pattern of knife used.

*Seasoning Pillars and Rails.*—It is an advantage if all the framing can be cut out to its approximate shape, and then stored in a warm place for a month or two, a plan which can be carried out with pillars and rails which conform, more or less, to a standard, but it is a method which does not by any means appeal to the

builder with no capital to outlay in this direction, or where a new shape of body calls for several pieces of stuff of unusual shape. It would, therefore, appear to be a wise plan if carriage builders would lay out their plans for body designs some time in advance of their actual construction, or at least, from an assembly of patterns used in the shop, determine various shapes of pillars and rails, which by a small allowance will make up into a fairly wide range of bodies, even taking into account the differences of chassis dimensions. A motor body builder is more likely to make his reputation by the faultless character of the framing after a year or two's wear rather than by striving after novel outlines built of partly seasoned timber. It is seldom that a body maker builds a body unaided; often a man and his mate take a body between them, while an experienced piece-man will have three or four on a job, and apportion out the work according to the experience of those under him.

*The Face Side.*—The horrors of "jacking up" the stuff, that is, getting the stuff into shape and a face side on the timber with the jack plane, is much a matter of the past for the apprentice, now that the sawmill whips off the necessary shavings in a very short time. Still there is plenty of occasion, even now, for accurate facing, for it is not always economical to be running to the sawmill, and timber often twists slightly after leaving the machine. The face side must be accurate, and pass the eye test with the winding sticks and straight edge, because from it the other sides are formed whether on the bevel or at right angles, and a true edge is also required so that joints can be scribed with precision.

*Joints.*—The joints used are the various modifications of the mortice and tenon, and lap joint. The theory underlying their use is that the pieces joined shall be weakened as little as possible, both in the design of the joint and its method of fastening, that the bearing surfaces shall be as nearly as possible perpendicular to the direction of the greatest strain, and that they shall be as simple as possible. Seasoned timber is again essential for well-fitting joints, as should a tenon shrink in a mortice it loses a great deal of its proper bearing surface, and results in as faulty a structure as if the joint were unskilfully made in the first instance.

The mortice and tenon is used at the junction of the standing pillars and cant rail, while stub tenons, that is, where the mortice

is blind or not carried through, are useful in framing the waist rail into the door pillars, thereby allowing an end fixing by means of screws. The half-lap is gaining in favour, and it is found a convenient joint in many parts of the framing, since it gives greater freedom in building up, and it is easier to judge whether the surfaces of the joint are bearing properly all over. The half-lap is also widely used in building up the seat panel framing of side entrance phaetons and closed bodies. Hoopsticks are notched into the cant rail, so that the ends of these thin rails shall be weakened as little as possible, while the cant rail is left sufficiently wide to allow for the notches being cut without unduly weakening it.

The floor boards are rabbeted into the bottom runners so as to give them an end bearing, which is usually the full depth of the board, and are left loose where inspection of the chassis is required. Rabbeting is also used to provide a shutting ledge as between the door and the standing pillars, cant rail, and bottom side, although this may not be carried out on both pillars or bottom side in cheap, side-entrance body work. A body is framed up so as to hide all joints as much as possible, therefore wood pins are not used to draw up a tenon if they will show from the outside when the job is finished. If screws are used for a fastening from the outside, they will be let well in, and afterwards covered with wooden plugs with grain to match the surrounding timber. Panel pins are driven below the surface, so that the small holes formed can be stopped up in the preliminary painting processes.

When a mortice is fastened with an oak pin, a hole is bored through both sides of the mortice and a corresponding one in the tenon, but this one is half the width of the hole nearer the shoulder of the joint. The two parts are then driven together and a tapered iron drift pin hammered in, which effectually draws up the tenon tightly when right home. The wood pin is then inserted and the end cleaned off flush. In some parts of the body a preference is shown by some body makers for the use of a haunched tenon. Advantages claimed are greater strength, especially if the main portion of the tenon is made a little thinner, and water is less likely to get in, but in the absence of actual tests this theory is open to question. A double tenon is sometimes used when it is thought that a large mortice would unduly weaken the stuff. The lap and

tenon joint is considered of service, especially if the tenon is a stub and the end grain of the lap can be hidden. There is no record available where body framing has deteriorated in service because all the joints were made of simple half-laps and plain mortices and tenons, and it would seem to be largely a waste of time and labour to devise ingenious double-haunched tenons and combinations of laps and tenons, which are difficult to fit on all their abutting surfaces, unless one is fully convinced that such a procedure makes a better wearing body.

*Framing-up.*—A convenient part to start on, in any motor body, is the bottom framing. The body maker will usually prefer to fit the bottom runner on the actual chassis to be used, especially if it is carved in profile, and has three-quarter elliptic springs at the back. If there are any bolt-heads, or other projections, on the top flange of the chassis, instead of gouging out the underside of the runner he may prefer to fit a thin filling-up piece first, so as to give a smoother bearing. The bottom runners are usually framed with cross bars (which are also rabbeted for the floor boards) wide enough to overhang the chassis even at the narrowest point, as this prevents the junction of body and chassis being visible under ordinary circumstances. The hind cross rail is usually framed in with some variety of tenon, and care must be taken to see that due provision is made for getting at the petrol tank, if it is slung at the rear, and it may happen also that the side framing will have to be neatly fitted round a projecting spring bracket. The body maker will be able to see now if the floorboards will properly clear the differential casing on the back axle, or any part of the mechanism which stands up above the level of the top of the chassis. Other cross rails, two or three in number, will be required, according to the length of the body, and their exact position will depend partly on the setting out of the engine transmission, and also on the design of the body. A cross rail at the foot of the hind standing pillar will be required, in order to take the fixing of a body-plate, which will run up the corresponding pillar on each side, and across the rail at their feet. This often is the main strengthening device in an open body in order to tie the two sides of the body together in the centre. Before the bottom is framed up, there is the consideration as to whether the rocker or boot sides below the seat-line shall be framed

and panelled, or made in the solid. One process makes a lighter yet more expensive job, but the unframed method is that usually adopted both for cheap and high-class work. If panelling is undertaken short pillars will be tenoned into the runner at the proper angle, so that the panel, when it bears upon them, will have the proper sail as indicated in the drawing. The framing will generally lie flush with the runner, so that the panel can be laid on overall to the base line of the runner.

*Wood Panelling.*—Panelling is chiefly carried out in mahogany, the Honduras variety being specified for good work, but owing to its scarcity, much timber is now used, coming from the same latitude in West Africa, which, if well selected, provides a good painting surface. Wood panels in old-fashioned, well-built horse carriages were largely retained in position by grooves made in the framing, in which also the mouldings were formed in the solid. This method demands increased skill from the body maker, not only in forming his grooves accurately with the router, but in driving the panel home, and according to the varying widths of the panel so its direction of being placed in position has to be judged. In driving seats of closed bodies, and in square-cornered landaulettes, examples of grooving are still met with, but the present-day tendency is for panels merely to be laid on, and metal mouldings afterwards planted on. Laying a panel on instead of driving it into a groove endways means more freedom in working, less restrictions in constructional design, greater ease of repair, less strain on the various parts, and less liability to the harbouring of dampness, which of course sets up rotting. Cedar and whitewood are also used for panelling.

*Framed and Solid Sides.*—Reverting to the building up of the bottom frame, if the job is not to be panelled, the solid side is got out of American birch, which is often purchased in a prepared condition. This is screwed to the runner from the outside, battened on the inside to resist warping, and forms a good foundation on which to build up the standing pillars and their bottom side, and in an open body the piece in the doorway is often afterwards cut out. The solid side requires that the body at this part shall be straight throughout, and if extra width is wanted at the hind standing pillars, a wedge-piece must be inserted. The framed side, however, has the advantage that it can be made to suit

exactly the design of body planned out. If more width is required at the foot of the pillars this can be done by making the runner wedge-shaped at the outside and contracting it again under those parts where there is no need for the extra dimension.

While the bottom of the body is thus being made, the doors will be undergoing framing up at another bench, while possibly a third body maker will be getting out the elbows and other rails so as to be in readiness when the body is put together.

In a limousine, the various parts of the main framework are planed up to their required size, the joints formed, and then each side of the body is put together separately before each part is finally boxed out, rabbeted, and grooved, so as to justify their general accuracy with regard to the side sweep. The standing pillars and bottom side are then offered up to the bottom framework already constructed, and screwed from the inside, after which the seat framing is fixed so that the light pillars can be attached. The front and back framing is then got on with, while as the erection proceeds, the body maker is careful to ascertain that each side is shaped alike, and that various parts are quite square, true to sweep, and dimension given, and so on. While a body is in course of erection wooden stretchers are fixed across at two or three points, so that the framing is held together firmly in the absence of the rails yet to be framed in, which will hold all together rigidly and finally.

In framing on, say a cant rail, the body maker has to test as to whether it is lying horizontally, and if not, it will necessitate taking a little off one or more shoulders of the tenons. If the body is to have metal panels, it will be transferred temporarily to another department, during which period the doors will be brought to a finish, having been first framed together and then taken apart and the grooves and wastings formed, while the driving seat and probably a hind locker door and a pair of front doors got forward with.

*Coach Joinery.*—Glass frames are now made of mahogany, tenoned together, the oak frame having gone out of use except when they are specially ordered to be covered in cloth. These frames, and also the heel boards and half-round fillets for finishing off the inside of the lights, are usually made by a coach joiner, whose work is confined practically to what may be termed the cabinet-making side of carriage building. He will also, if a skilled worker, make

any actual cabinet work, such as is formed in the luxurious bodies of to-day.

The fence, waist, or middle door rail, if more than 5 ins. deep, may be two separate rails panelled over. More often it is a solid $1\frac{1}{4}$-in. piece of ash. On the top it provides a bearing for the glass frame when up, and to the back is screwed a strip of metal or fence plate which keeps the frame from slipping backwards after it has been lifted over the fence, while the shape of the run in the door pillars prevents its forward movement. Below the fence is the wasting, which is a lightening out or rebate adopted all round the light, and therefore is found on the inner edge of the door pillars, and on the bottom of the door top. The front surface of the door rails conforms to the side sweep of the body, while the door top is open at the top so that the glass frame can be inserted and withdrawn. In a limousine the hind standing pillar has a glass run formed in it, so that the side light may be lowered, and usually the substance of this pillar is kept the same measurement of 2 ins. as the door pillar, so that neither pillar has any tendency to be the more prominent, although, below, the standing pillar is increased to about $2\frac{3}{4}$ ins. to withstand the extra weight and strain which has to be borne. The side light has its other run in a special light pillar which is framed in for that purpose, and whatever shape the light may be, the standing and light pillars must provide a pair of runs which shall be absolutely straight and parallel, otherwise the frame will either bind or rattle.

This light pillar is framed into the cant rail similarly to the standing pillars and will be checked or notched into the seat frame.

*Door Hinges, Locks, and Dovetails.*—The hanging of doors requires considerable experience, which gives the workman the necessary judgment in order that he may readily adjust any faults which arise when testing the shutting of the door. As the door has a turnunder, and it is desirable for it to open square, a line passing through the hinge pin centres must be vertical, and all pin axes lie exactly in the same line. Various types of hinges are marketed, some having cranks so that the door will throw well out so as to clear a closely fitted wing or to give the full benefit of the width of the door opening, instead of the thickness of the door detracting from the available entrance. The concealed hinge, which has gone

out of fashion, is a type in which the mechanism is let into the body of the pillar, and nothing is visible when the door is shut; this pattern requires a certain dimension of pillar for its introduction, and often the pillar is nearly severed at the hinge position. When there is, say, a 6-in. turnunder, it would be inartistic to fit a large butt hinge, so that an outrigger of wrought-iron is utilized, which is brought out so that the turning centre conforms to the pin line of the upper hinges, while long flaps are provided, one of which is screwed to the door bottom and the other to the pillar and bottom side.

The door lock is a factor in maintaining the effective working of the door. It is a slam lock (really a latch) provided with a long top lever, which by passing through a convenient slot in the garnish rail, allows the door to be easily opened from the inside, or the inside handle may be fitted directly to the same centre as the outside handle. The wearing of the bolt of the lock is taken by a gun-metal striking plate, and as this wears so the door consequently loses its tightness, and commences to rattle, unless a well-made adjustable plate is used. The door is also kept in its proper position by means of metal dovetails, the male portion of which is fitted to the door and the other part to the standing pillar. One or two may be fitted well above and below the lock, and as an extra precaution also on the door bottom. These wear in time like the striking plate, unless wear is allowed for by adjustment.

*Folding Head Ironwork.*—In landaulettes there are various hinges and catches to fit which make up the mechanism of the folding head, and the introduction of landaulettes with long quarters, and various types of cabriolets, has brought many fresh patterns before the motor-body builder. The number of hinges fitted will vary according to the extent of folding required. If the front pillars fold, there will be a pair of hinges to let in so that the pillar top may fold above the fence line, and if the body is well finished a brass plate will be screwed on the end grain to make a good job. Then the front top rail will be attached only to the cant rails, and fastened, when the head is shut, by means of a pair of pillar catches. There will be a centre hinge if the cant rail itself folds so as to foreshorten the head; while the pillar hinge will require a strong flap well screwed to the back of the pillar top, and along the top of

the elbow. The head, when down, will lie on a pair of body props, well flapped and screwed to the elbow and hind rail. When the pillars fold the glass frame will be provided with an extension of its glass run hinged at the cut of the pillar. These fittings are known as glass frame supports, and when the head is up these are recessed into the pillar top above, which means, if a good job is to be made of it, that the wastings must be made larger than usual, so as to accommodate the supports without unduly breaking the lines of the door.

*Panel Canvasing and Blocking.*—Panels are maintained in contour by the provision of battens which lie close up against the back of the panel, and may be placed either longitudinally or transversely, according to taste. Wood panels are strengthened by being canvassed on the cleaned yet unplaned back, while, at the junction of a rail or batten, small blocks are glued on, which also increase the rigidity of the panel fixing, a plan which is carried to great extremes by some builders, who consider it necessary to fill up the whole available inside surface of the panel with wood blocks. A similar process is carried out with the roof, which may be in one piece of three-ply, but if it is made up with boards, these should lie longitudinally, and be as narrow as possible, consistent with economy in labour, as there is less liability to contraction at the joints, while the centre board is made slightly wedge-shaped so as to make a tight job. Door bottoms are bored on the underside so that any water getting into the door casing may have some chance of escaping, a very necessary precaution if a frameless light is used which slides in a velvet-lined metal run, and does not shed the water so easily as the more common pattern. Joints are driven with white lead so that the surfaces are well preserved and held, and screws are inevitably used throughout, except in such positions as the fixing of a panel or roof board. In order to provide a foundation for the trimmer's work, the lining boards of the doors and front are of good $\frac{1}{2}$-in. birch, while various trimming pieces will be provided at the sides and back of the body for fixing the other portions of the lining.

The body is bolted to the chassis by bolts passing downwards through the runners and the flanges of the chassis, unless special brackets are provided for the purpose, as in the Daimler chassis.

Regarding further details, if an extension roof canopy is provided to the driving seat, this will be framed with a heavier rail immediately over the dashboard, so that the upper half of the wind screen may be attached if it hinges from the top. Some form of splice will be necessary to joint up the side canopy rails with their front rail, which will be kept flat and not conform to the rise in the roof, as it is generally considered that a piece of framing which is curved at the corners in plan, and rises in the centre in elevation, gives a ram's horn style of decoration, which, to say the least, is not restful to the eye, and the same idea is carried out with a D-fronted body. If the canopy is detachable, then the cornice which hides the join of the roof canvas or moleskin will not run along the side of the canopy, but turn and proceed across the front top rail, while a separate piece is fitted to the canopy. The wooden cornice will have to be eased round the sharp corner in front by gently steaming it, and making a few saw cuts on the inside, and similarly at the rear, if it is continued round the back of the body.

*Bent Timber.*—Bent timber is not so much used in motor bodies as in carriages. Examples of its use are the D-fronts of limousines and landaulettes, and sometimes the elbow and back rails of open cars. Straight-backed seat panels are also occasionally made in this way.

*Open Body Construction.*—In the modern style of open body, with all its outside panelling reaching down to the chassis, the vertical members of the framing are jointed directly into the bottom runner. As the runner is kept as light as possible, the tenons at the foot of the standing pillars do not give a great amount of stability, bearing in mind that they are not tied at the top as in a closed body, so that the use of strap bolts is to be recommended, with the plain end turned in.

In framing up the elbow rails of open bodies, and also the corresponding parts in a limousine, there is, unless bent timber is used, a considerable amount of work entailed in getting out the curved portions, as the rail not only rises in elevation, and is bevelled in two directions, but it is also curved in plan. Five separate pieces are necessary, and a thick piece of stuff will be required at each corner in order to form out of the solid the

necessary bevelled and curved surfaces. The first portion in the straight after it leaves the pillar is simply got out to the proper dimensions, and bevelled to correspond with the side sail; the next piece, which follows immediately after, has to be got out of thicker stuff, because the curve in plan begins while the bevelling is gradually increased to the additional amount which is present at the back. The corner piece will require timber from $2\frac{1}{2}$ ins. to 3 ins. square, from which the back bevel is first taken off, and then a square line formed which will correspond to the joint with the second piece, leaving a fair margin for final working up. This corner piece is then shaped to the curve in plan, after which the superfluous timber is dressed off, and the operation repeated on the other side. The operation may be varied by glueing a piece on at the corner and shaping up when hard and dry.

# CHAPTER VIII

## *MOUNTING*

*Comfortable Driving Position.*—Even if the body maker builds the body directly on to the chassis, instead of on the shop trestles, the body has yet to be mounted in the technical sense. This is usually carried out in a separate department. If the chassis has only just arrived, the bottom runners have to be justified, so that they snugly fit all round. Sometimes a lining piece will be fitted, as already mentioned under body making, or if the rise in the chassis is not greater than two inches, the lining piece will be bolted on the lower part of the chassis only, so that a flat bearing for the body is obtained. If the body is to slide, this method becomes a necessity. Various degrees of cutting away will proceed by the lever quadrant, the front of the runners will be fitted to any bracket piece supplied, so as to join up neatly, and the comfort of the steering wheel and pedals tested with an old cushion. If the client should call he may test his arm and leg reach now, and the body be slid along the chassis a little either way, if required, so long as it does not interfere unduly with the door clearance of the hind wings. This operation may entail a considerable amount of work in modifying the shape of the under surface of the runner if it has already been fitted and the frame has a curved profile, or if it reveals the hind cross member of the chassis. If a canopy is fitted the rail above the dashboard is tested to see that it is directly above the dashboard. Now that scuttle dashes are used so frequently, the mounter does less work in the front of the body than formerly, for it was not unusual for him to hang the front doors from a piece of ash screwed or bolted to the dashboard, and build up round the dashboard as required, in order to fit the bottom portion of the wind screen. If the tank is situated under the front seat, the necessary clearances have to be watched, and if a special tank is being made in the

metal department, he will probably fit it and bore any necessary hole for the filler. It is his duty to fit the canopy stanchions, and bolt the sockets on, and he marks the frame where the step stays are to be bolted on. In drilling the frame for these and the holding down bolts of the body it is a great convenience if a portable electric drill is provided, or one driven through a flexible shaft, as the boring by a hand ratchet drill is very laborious, and often requires an extra man to assist, especially when the web of the frame is being drilled.

*Fitting Wings and Long Side Steps.*—The long side steps are then got out, usually the full width of the wings, so that the front edge is 3 ins. in front of the tyres, and bolted temporarily to the stays, so that the wings, which have meanwhile been made in the metal department, or obtained from a factory where a speciality is made of these goods, can be cramped on in position, and the positions marked for the wing stays with their bolt holes. Sometimes the step is swelled out by the main entrance so as to give a wider tread. The front wing stays should be fitted to sockets bolted to the frame, so that they may be easily removed when overhauling the engine, while the flaps, in all cases, should not merely hold the wing, but pass under it both longitudinally and transversely, so that the free ends do not vibrate unduly and break away at the bolt holes. The hind wing stays are often fastened to the chassis as well as the body, and it seldom happens that, when it becomes necessary to dismount the body, it can be carried out without detaching the hind wings.

The inner ends of the front wings are usually bolted to the ends of the step board underneath, and if side guards are used these have to be fitted to the chassis, and if of metal will be made, as a rule, in one piece with the wing. The inner end of the hind wing is usually fastened to the step by an angle plate finished to match the step edging.

The wings are then detached with the flaps attached and sent into the paint shop, while the step boards will go into the metal department to be fitted with their brass or nickel angle plate, which is soldered at the corners, and an angle piece provided for attaching the hind wing. The made-up piece of angle plate, after polishing, is ready for screwing to the stepboard after it has been given a coat of paint underneath, and covered with the usual rubber or aluminium

matting, or linoleum. Before this is laid on, however, the wood countersunk bolts are dropped in for attachment to the step stays.

*Step Lockers.*—The step boards may be fitted up with lockers or drawers, while the top may form a series of lids, or, as is often done, a metal well, with one or two holes provided to let out the wet, is furnished on the offside to carry the spare tyre, detachable rim, or wheel. When lockers are formed in the step, it is advisable to make the lid in two pieces, otherwise it will be very heavy, and handles may conveniently be screwed on the front edge. The locker itself is best lined in sheet zinc with, say, a three-quarter inch lip standing up, into which the lid recesses, thereby making as circuitous a path as possible for the water. If such a locker is considered unsightly the front of it may be swept backwards so as to be invisible from the outside when the observer is standing. Some bodies are made to hinge from the rear and have attached at the front on each side a hinged metal strut, which may be provided with springs so as to assist the body in rising.

*The Coach Finisher, Fitter, and Inspector.*—In large shops the mounter will be responsible for making the step boards, the final fitting of the floor boards, marking the stays and fitting them with the wings, and also any luggage rail or rack required, and he will usually finally mount the stanchions. A separate workman, sometimes called a fitter, takes over the car when it has left the paint shop, and mounts the finished wings and steps, fits up any gas piping or wiring needed for the lamps, looks after tyre carriers, and other miscellaneous fittings, and puts on the wheels (sometimes tyres) and bonnet, and fixes the luggage rack or carrier, lamp brackets, hooter, speedometer, and so on. The joiner, or may be a finisher, puts in the glass frames, attaches their strings, mounts the wind shield, screws on the filleting round the inside of the lights, and may be puts in the door handles, and fits the slot plates for the top levers to work in.

The cape cart hood framework is often made by the mounter rather than the body maker, and he will finally bolt on the body irons to carry it, and attach it when finished by the trimmer.

The finished car, in a large factory, has to pass the scrutiny of an inspector, whose duty it is to criticize the general completeness of things, see that no detail is missing or defect present, and compare the car and its fittings with the accepted specification.

# CHAPTER IX

## *COMFORT IN THE MOTOR BODY*

*The Function of the Upholstery.*—One of the chief differences between a public-service vehicle and a private one, and between a cheap and an expensive one, is the luxury of the interior trimming or upholstery, and the accompanying degree of comfort to the passenger. Pneumatic tyres, and the springs of the chassis, go a long way towards insulating the occupants of the body from road shocks, but well-arranged trimming further removes vibration, and gives a soft and resilient seat as well as a resting-place for the back and shoulders, the whole being also set out with a view to decorating the interior.

The cushions and squabs used in trimming not only act as pads to keep the person away from the hard wooden structure of the body, but the materials with which they are built up are chosen with regard to their resilience, and shape-retaining qualities. Series of coiled springs form the foundation of most trimming work, over which is laid curled horsehair, with a layer of cotton wool or batting to prevent it working through the outer cloth or leather covering.

*Cushions.*—Successful trimming, giving comfortable seats, depends greatly on the arrangement of the woodwork. If a seat-board has been fixed in without any drop to the rear, the trimmer may counteract it by making his cushion thicker in front, but the cushion will still tend to slide off. If the seat is properly sloped the cushion may be of the proper thickness both at front and rear. The trimmer can easily raise the level of the seat by a thicker cushion, but he cannot lower it if it has been badly placed unless he puts in a thin and often hard cushion. He likewise cannot apportion out what head, knee, and leg room he thinks desirable, but must take things as he finds them. Occasionally in emergencies

the width of a seat from back to front may be slightly increased, but then again this is probably at the expense of knee room. It is therefore important that the design should be well thought out before the trimming stage is reached, as little can be corrected after the body is once framed together.

*Squabbing.*—Apart from designing a cushion so that it throws the occupant naturally on to the back squab, the squab itself must be shaped without any fulness lengthwise in the centre, so that the passenger is not thrown towards the ends of the seat. The vertical fulness must be constructed so that it fits well into and supports the back, and must be high enough to rest the shoulders, and if desired the head as well. Inside elbows should be low enough to form a comfortable resting for the forearm, and dropped at the rear to follow the inclination of the seat. If the hand is to be supported in a pillar holder it will be hung at a convenient height and within easy reach.

Apart from these elementary considerations, if cloth is used as a lining material it will be cut out and made up so that the cloth brushes towards the front of the cushion, and also down the sides and back; pleating will not be indulged in beyond what is necessary to retain the stuffing material in proper position, any excess being a harbourer of dust.

*Colour and Quality of the Cloth.*—From the decorative point of view, the colouring will follow the personal wishes of the purchaser, but it may be pointed out that indigo and some browns are dyes which do not impair the strength of the cloth, while others, like green and black, are not so desirable from this point of view. Other colours will fade, while on the other hand some will not show the dust readily. Durability is largely a matter of price, the best "West of England" cloth being unsurpassed in this direction. Cheaper materials will have varying mixtures of cotton and be perhaps piece dyed instead of being so treated before weaving.

*Leather.*—Leather is usually considered more hygienic; morocco gives a luxurious appearance, and is expensive, but it is water-dyed and not suitable for an open carriage. Stronger leathers such as buffalo hides, which are painted, form one of the chief materials for side-entrance phaetons and the driving seats of all types of bodies.

*Floor Comfort.*—Comfort for the feet does not always receive that amount of attention devoted to the ease of other parts of the body. The floor of a body is often quite flat, and where a body has been mounted on a chassis having a rise at the back, an awkward slope in the body may result. If the floor cannot be curved, a foot-stool should be provided, so that the feet are kept at about right angles with the legs.

*Where Padding is restricted.*—In trimming a body, the whole width has to be kept within narrow limits; the side padding will not be as generous as at the back squab, while the treatment of doors and the sides of gangways will be flatter still, so as to give an artistic effect with the least possible thickness. Padding is not always confined to the position occupied, but it may be seen used above the elbow. This style is not to be recommended, and it must be admitted that the plain work above contrasts pleasantly with that below, and harbours less dust.

*The use of Coach Laces.*—In the same way that a moulding defines the shape of a panel, and often hides its connection with the framing, so the seaming, pasting, and broad laces fulfil a similar office with the upholstery. Seaming lace, as its name implies, hides the seams of the work, and when sewn to the edge of a piece of material provides a means of fixing it. Pasting lace, by means of its tape edge, can be fastened over any nail heads showing in the work, while the other side is brought over and pasted, thereby effectually concealing all beneath it. The broad laces, which run up to 3 ins. wide, may be found outlining the central portion of the door or as a close edge lace forming a glass string or pillar holder, in which case they are finished with a tassel.

*Unsightly Glass Strings.*—Glass strings are often dispensed with when there is a light by the side of a seat, as in a large limousine, for here it would be in the way, and a glass frog-holder is used instead. When mechanical devices have been perfected, or even those available better known and appreciated, there is no doubt that the cumbersome glass string to the door and other lights will be seen no more, as with its guard string for preventing it wedging in the glass run, it is not a beautiful object when its back has been stiffened up with morocco, and always the neat design of the door is spoilt by this curling arrangement of lace and string.

*The Importance of Comfort in a Motor Car.*—Comfort in the motor body is of greater importance than with a horse-drawn carriage, chiefly because of the greater speed attained, the longer journeys undertaken, and since road travel is indulged in more freely because of the increased capacity of the car. Therefore, though horse-drawn broughams and landaus may have given the acme of comfort to their users under more restricted conditions, one must expect some difference made to allow for the greater utility of the automobile. Modern design in the seats of motor cars tends towards making them lower with more rake, and the greater dependence on coiled springs rather than horsehair for resilience. A slope of from 1 in. to 1½ ins. should be sufficient to the seatboard, and the cushion, as suggested before, should be parallel, so that it can be economically and simply built up. Opinion is divided as to whether the coach trimmer should follow the furniture upholsterer closely with regard to the somewhat excessive springing indulged in in the design of sofas and lounges. If an equal amount of comfort can be gained from a 5-in. cushion as from a 10-in. cushion, then the difference is so much wasted locker space, and needless expense on coiled wire and cushion covering. As in other departments of motor construction, one has to find a mean between comfort on the one hand and usefulness on the other; and one cannot expect the convenience of a stationary house in a moving vehicle.

*Trimming Accessories.*—Apart from the actual trimming, there are several accessories which call for remark. Generally one or two companions or cantines are fitted. These consist of small cabinets attached to the sides of the car within easy reach, and contain such items as a note-book, card case, scent or salts bottle, and watch, while those devoted to the needs of smokers have a match box, ash tray, and cigar cutter, while the electric cigar lighter is a separate fitting. Umbrella holders are usually screwed to the front lining boards, although this is hardly so happy a position as the "sword case" of our great-grandfathers' chariots. Mirrors are generally tucked away in the lady's companion, but they may be fitted up to the inside of the car itself, and it is not unknown for them to be attached to the rear of the hand holder. In the roof is often fitted a hat and parcel rack, consisting of a network of silk cord, but it can hardly be classified as an accessory of real service.

*Cabinet Work.*—Cabinet work has always been fashionable. In the earliest types of bodies, lockers, with cleverly shaped curved doors finished in polished woodwork, were to be found underneath the two hind corner seats. Nowadays, the whole of the D-front of a limousine may be given up to one large, tall cabinet, reaching from floor to roof, replete with writing, toilet, luncheon, tea, and medicinal requisites. The folding polished table is an accessory which has always found favour, and sometimes these are arranged to meet in the centre of the body, and fold down on opposite sides. Polished woodwork is used to finish off the wastings of the lights, while the glass frames, the under-surface of the canopy, the heel-boards, sometimes the inside of the body above the elbow, and outside tool-boxes are also finished in this way.

All these fittings should be as unobtrusive as possible, and if they can be let into the framework of the body, so much the better from the artistic point of view. Most chassis, being about 24 ins. off the ground, the planning out of steps to the body, of a suitable height, is seldom difficult. The long side or platform step forms a convenient and broad landing. The popularity of the cardan drive car has done away with the drawbacks of chain cases and the accompanying awkward steps. It is not often necessary to provide a second step unless the owner is an invalid, and has to be assisted, otherwise it is liable to become a source of danger.

*Conveniently placed Handles.*—The handle of the door is placed primarily so that it will hold the door tightly between its top and bottom bearings. In some landaulettes, and all phaetons, this is generally accomplished by keeping it high enough to be within convenient reach. The top lever handle is a luxury generally found in closed bodies, and if used in an open car, the usual outside handle is hardly necessary, and, in fact, has been done away with in some flush-sided phaetons, so as so preserve the general neatness aimed at.

*Pockets.*—The pocket formed in the trimming still continues in favour. If made up in the back of the door, it generally lends itself to shabbiness; on the side of the body in a long car it is perhaps in its best position. In the absence of folding seats on the lining boards, a pair of pockets may be placed there. The driving seat side squabs are often equipped in this manner. The motorist who

wishes to retain the neatness of his car will not favour this type of "locker," but will endeavour to keep small odds and ends in a drawer or tray of a neat cabinet, fitted up inside the car.

*Blinds.*—Most closed cars are fitted with blinds, generally of silk (lute-string). They are rarely used by the passengers, are a source of trouble, especially with a landaulette, and should be avoided.

*Ventilation.*—Apart from cost, the chief advantage claimed for the open phaeton over the limousine is the greater amount of fresh air afforded. One is inclined to think, however, that the alleged stuffiness of closed cars, together with the draughts created, is often exaggerated, and likewise the disadvantage of driving at a good pace against a fresh breeze is not always boldly stated. The whole question, as between closed and open cars, is a very important one, and every new pattern of landaulette, cabriolet, and allied type, shows the amount of activity which is being directed towards the solution of the difficulty. If one lowers all the windows of a large limousine, with perhaps the assistance of a roof ventilator, it cannot be said with any great degree of truth that the interior is not well supplied with fresh air. The chief drawbacks to a closed body are weight and consequent wear of the tyres, and general increased cost of upkeep; besides, the strictly limousine and landaulette types are not considered self-driving cars unless the front is enclosed, has a leather canopy, or is of a certain not clearly defined outline.

The purity of the air in the interior of a limousine depends on the number of occupants, the size of the car, and the position of the entrances and exits for pure and vitiated air respectively. A fair-sized limousine has some 88 cubic feet of air in it, which is insufficient even for one occupant, unless the air is continually changed. The warm, impure atmosphere is lighter than fresh air, consequently it tends to rise, so that permanent ventilators under the cant rail are of importance in this direction, while a clerestory is the best possible type of ventilator which can be utilized for the exit of air, and it should be designed so that incoming currents driven in as the car proceeds do not interfere with the object. Little has been done in private motor work to ventilate the body without dropping the lights, although it is obligatory in hackney carriages, licensed in London. Occasionally the top stile of a light may be

furnished with a ventilator, and the use of various devices for communication with the driver in lieu of a speaking tube could be made to fulfil this office. Roof torpedo ventilators are sometimes seen, as used in railway carriage work.

*Heating.*—Closely allied to ventilating is heating. Although the feet may be encased in foot muffs, and thick boots and stockings, this method does not appeal to many. The footwarmer is at last a well-designed accessory of the car's equipment, and, as may be supposed, depends on the exhaust for its heating. The brick heater, which has been successfully used for some years before the days of motoring, is also available.

# CHAPTER X

## *THE DECORATION OF THE CAR*

The decoration of the interior has already been referred to in the previous chapter. With the exterior one comes more closely in touch with the subject, as apart from the necessary preservation afforded by the painting, the ultimate idea is to embellish the car as a whole, giving it a beautiful appearance, a quality which is generally, at the same time, an indication of the personal tastes of the owner.

*Harmony between Panels and Trimmings.*—In deciding on a colour scheme, the exterior should be finished to harmonize with the colours chosen for the leather or cloth inside; especially is this necessary in an open car, while with a limousine one should aim at a harmonious effect when the door is opened. The choice of a suitable colour is often a tedious process, and very often the carriage builder is asked to advise, and if he is a wideawake man, he will have a selection of fairly large panels, finished neatly with a moulding, which are painted, fine lined, and varnished in various leading styles. The lady motorist is often the one who has this responsibility laid upon her, and as she often has a similar problem to face in the world of dress, it is not surprising that the duty is carried out with every success.

*Dark Colours a Safe Plan.*—To those who may be choosing a colour scheme for the first time, it may be pointed out that dark green, or blue with black mouldings, and black upper parts and rockers, is always a safe plan to go upon, while dark browns, red, and lakes look well and give a somewhat livelier appearance. The lighter body colours, such as a light red, yellow, mauve, and light green and blue, are now usually avoided, but those with sporting tastes or family colours to consider follow their bent, having as a result a very smart car, although the colours seldom wear so well

and are liable to fade. Quiet colours are usually understood to be inseparable from the best class of gentleman's carriage, and on the whole they wear better, and are more effective when varnished. For the edging lines to the mouldings, wheels and springs, the lighter colours are in demand as a rule, and when used sparingly help to define the outline and leading parts of the car without being obtrusive. The chassis or underworks may also be painted in contrast to the body, a plan which is not so much adopted as formerly, but was the fashion with sporting horse-drawn vehicles.

*Some Actual Colour Schemes.*—As a guide, some tables are given in order to indicate a few schemes of colouration. In any of the schemes, brass or nickel furniture is suitable, the term "furniture" including the lamps, door, and ascending handles, step edging and beading on the body, if not japanned. Glass frames may be polished or varnished in mahogany, rosewood, walnut, or oak, or covered to match the upper trimming of the car either both sides or on the inside only when the outside is polished, or the polishing may be of two different shades with the lighter one inside. Metal frames are sometimes used to match the furniture, but it is rather suggestive of a hansom cab.

| Body panels, with or without bonnet. | Fine edging lines or broad centre lines for *Black Mouldings*. Relieving lines are seldom omitted. | If not black mouldings or wings. | If not black rocker or boot panels below seat line, and black upper parts if closed body. | Chassis with or without bonnet, if not to match body. | Trimming. |
|---|---|---|---|---|---|
| Dark blue. | White, any red, any blue lighter than the body colour. All shades of yellow, gold. | To match, or lighter blue with black lines or as Col. 2. | To match, body colour. | Yellow with black lines, red with black or white lines, light blue with black or dark blue lines. | Dark or light blue, red, fawn, drab. The last two colours may be used for top only with other colours in contrast below for closed cars. |
| Dark green. | White, red, yellow, gold. | Ditto, but green, instead of blue. | Ditto. | Ditto, but green instead of blue. | Ditto, but green instead of blue. |

| Body panels, with or without bonnet. | Fine edging lines or broad centre lines for *Black Mouldings*. Relieving lines are seldom omitted. | If not black mouldings or wings. | If not black rocker or boot panels below seat line, and black upper parts if closed body. | Chassis with or without bonnet, if not to match body. | Trimming. |
|---|---|---|---|---|---|
| Dark purple lake. | White, vermilion. | To match with lines as Col. 2. | Ditto. | Vermilion with black lines. | Blue, red, fawn, or drab, or last two colours for upper parts only. |
| Black. | Any colour. | — | — | White, red, or yellow, with black lines. | Any colour. |
| White. | Ditto. | White with any colour line. | White. | Cream with red, blue, or green lines. | Ditto. |
| Dark brown. | Yellow, red, white, gold. | To match, or lighter brown, with black lines or as Col. 2. | To match body colour. | Yellow, red, or lighter brown, with black lines light blue, with yellow lines. | Brown, red, fawn, drab, or last two as upper colours in combination with brown or red. |
| Light blue. | White, yellow, gold, dark blue. | To match, or darker blue with black lines or as Col. 2. | To match, or dark blue. | To match, or dark blue. | Dark or light blue, brown, fawn, drab. |
| Light green. | As above, but substituting green for blue. | | | | Dark or light green, black. |
| Bright red. | White, yellow, or dark red. | To match, or darker red, with black lines or as Col. 2. | To match, or darker red. | To match, or darker red. | Most shades of red. |

| Body panels, with or without bonnet. | Fine edging lines or broad centre lines for *Black Mouldings*. Relieving lines are soldom omitted. | If not black mouldings or wings. | If not black rocker or boot panels below seat line, and black upper parts if closed body. | Chassis with or without bonnet, if not to match body. | Trimming. |
|---|---|---|---|---|---|
| Yellow. | No fine lines, with black lines. | To match. | To match. | Deeper, or lighter shade than body colour. | Blue, fawn, drab, black. |
| Grey (lead colour). | White, red. | To match. | To match. | Black, white, red. | Black, red. |

COLOUR SCHEMES USED BY ROYALTY AND THE NOBILITY.

| Body colour. | Relieving lines | Chassis. | Relieving lines. | Furniture. | Trimming. |
|---|---|---|---|---|---|
| | Private or Plain Royal Colours. | | | | |
| Dark purple lake. | Vermilion centre line. | — | — | Brass. | Indigo blue. |
| | H.M. The Queen Mother. | | | | |
| White. | — | — | — | Silver. | Crimson morocco and drab cloth. |
| | H.M. Queen Mary. | | | | |
| Green. | Lighter green. | — | — | — | — |
| | His Grace the Duke of Abercorn. | | | | |
| Crimson lake. | White. | Crimson lake. | Black, centred and edged white. | Brass. | Blue morocco. |
| | The Most Hon. the Marquis of Lansdowne. | | | | |
| Claret. | Red. | Chassis red, bonnet claret. | Chassis black, bonnet black, and centred red. | Brass. | Mottled cloth. |
| | His Grace the Duke of Marlborough. | | | | |
| Crimson lake. | Black. | — | — | Silver. | Brown morocco and cloth. |

| Body colour. | Relieving lines. | Chassis. | Relieving lines. | Furniture. | Trimming. |
|---|---|---|---|---|---|
| | His Grace the Duke of Rutland. | | | | |
| Blue. | — | Blue. | Black, edged light blue. | Brass. | Mottled cloth. |
| | The Most Hon. the Marquis of Salisbury. | | | | |
| Ultra-marine blue. | Black. | — | — | Silver. | Blue morocco and cloth. |
| | His Grace the Duke of Westminster. | | | | |
| Blue. | Deep orange chrome. | — | — | Brass. | Blue morocco and cloth. |

The above colour schemes were supplied by Messrs. Hooper & Co., Ltd.

| | | | | | |
|---|---|---|---|---|---|
| | H.S.H. Prince Hatzfeldt. | | | | |
| Black. | Yellow. | Yellow. | Black. | Brass. | Black cloth and leather. |
| | The Rt. Hon. the Earl of Mar and Kellie. | | | | |
| Ultra-marine blue. | Black, and fine lines of primrose yellow. | — | — | Brass. | Drab cloth. |
| | The Rt. Hon. the Earl of Clarendon. | | | | |
| Chocolate brown. | Pale blue and fine white lines. | — | — | Brass. | Fawn cloth. |
| | The Rt. Hon. the Earl of Londesborough. | | | | |
| Ultra-marine blue. | White. | — | — | Silver. | Blue morocco. |
| | Her Grace the Duchess of Hamilton. | | | | |
| Dark maroon. | Straw yellow. | Dark maroon. | Black, and fine lines of straw yellow. | Brass. | Maroon leather. |
| | The Rt. Hon. the Earl Cowley. | | | | |
| Chocolate brown. | Cream and fine lines of red. | — | — | Brass. | Brown morocco. |

N.B.—It is usual to trim the driving seat in buffalo hide to match the body colour, whatever may be the material and colour of the trimming used inside a closed car.

*Striping.*—As indicated above, the usual way of relieving a body or chassis colour is by a fine line. With the chassis (including the bonnet) sometimes two fine lines are used, called double fine-lining, with or without a broad picking out line in the centre, or the broad line may be used alone. One sometimes sees more than one colour used when there is more than one relieving line, and unless the vehicle is at rest any elaboration is entirely lost to the onlooker. Centreing is sometimes adopted, which consists in using a narrow line in relief in the centre of a wider one. The body panels are often striped. This may be either as a broad stripe, say an inch wide, or a series of, say, three fine lines occupying together one inch of panel, each series being set about $1\frac{3}{4}$ ins. apart, and occasionally the broad stripes are relieved with a lighter fine line either side. The colouring of the stripes and fine lines is generally carried out in gentle contrast.

The stripe colour may be looked upon as a moulding, and reference to cols. 2 and 3 of the tables just given will give a general idea as to what may be done in this direction.

*Caning and Basketwork.*—Another means of decorating the body consists in applying sham cane or basket work to the belt panel, or in a few instances, the whole body. The sham caning is bought in sheets all ready to stick on to the panel surface required, and may generally be recognized owing to the fact that the ready-made article seldom allows for the bevels, curves, outlines of the mouldings, and other peculiarities of each body. Sham caning, when done by hand, is put on by means of a tube tool, and the number of coachpainters who are capable of doing this is very small, as there is so little call for it.

*Bevelled Glass.*—Some motorists desire to make their cars look more sumptuous by using bevelled plate-glass to the lights. It is not to be recommended from the utilitarian point of view, as the line of vision is obstructed through the bevel, a broken glass takes longer to replace, and the whole light is made heavier.

*Polished and Varnished Woodwork.*—Polished woodwork has already been mentioned. There is another scheme of body decoration which is not made as much use of as might be, and that is when the car is finished in the natural or varnished wood. When the timber has been carefully selected, and the filling up of the grain of

the wood successfully done, a fine result is achieved. This finish is desirable for shooting brakes, and may be used for closed cars if the owner wishes to have a distinctive finish.

The extensive use of metal panels precludes this varnished wood style of finish for most touring cars, but designs can always be obtained from the carriage builder where wood panels and framing can be used throughout. It is a colour which does not show the dust readily, and therefore admirably adapted for touring cars. Black mouldings and ironwork are often a part of the scheme, while a fine line of red looks well. The use of metal panels has suggested to the client, in some instances, the finishing of the body in aluminium paint or with polished panels. Either of these schemes has the drawback of retaining its freshness only for a very short period.

*The Time-factor in Painting*,—The carriage builder is often grumbled at for the time taken in bringing the body from the bare wood to the last coat of varnish. During the last seventy or eighty years, or even more, practically nothing has been done to hasten the process. In this era of hurry it is natural that this slow method should have received a large amount of well-deserved criticism. The time taken for painting, not only extends to the last coat of varnish, but, to give satisfaction, a week should be allowed for the varnish to harden, which, as might be expected, has often resulted in the car being taken away before this extra time has elapsed, the consequence being a readily dulled panel surface, so naturally the motorist eagerly awaits a quicker, if not a cheaper, process.

If bodies were made more extensively of metal we should hear more of stove enamelling, which is certainly a quicker and cheaper process, and those who are familiar with the wear and tear a well-finished bicycle will stand can form some idea of the durability this process possesses. From the practical point of view, it would prevent any trimming being done on the body until the last coat of enamel had been stoved and hardened, which would tend to counter-balance some of the time saved on the painting. At the present time, it is usual for the trimmer to do the best part of his work before the car enters the varnish room, so that the body is handled as little as possible after being varnished. Motoring has many more adherents than ever owned horse-drawn carriages, consequently many become

vehicle owners for the first time. This has meant a large amount of extra criticism being levelled at the carriage builder, and an ever-recurring topic in the columns of the motor weeklies is the subject of the tediousness of painting. A motorist, for instance, familiar with the time expended on painting a mansion, cannot at first realize the necessity for six weeks to paint a body which has about as much surface to paint as a butler's pantry. Some motorists content themselves with dull, unvarnished panels finished in lead colour, which they can touch up as required; others ask for various cold enamel paints to be used, so that some of the coats of paint may be omitted. A well-painted horse-carriage lasts five or six years, with an annual coat of varnish, but the motor car, travelling at a greater speed, often in less favourable weather, and covering more miles in the same time, has its panels dulled much sooner. More durable varnishes have not yet been discovered for the extra stress entailed with the automobile, therefore repainting should be carried out more frequently, and perhaps it would be a wiser plan with the man who uses his car often and for fairly long journeys, to have the painting done with less coats and repainted each year, rather than copying the older method exactly and expecting it to last as long. Painting, from the practical point of view, is described in the next chapter. The quicker processes are also described, likewise the procedure with regard to enamelling.

*Metal Fittings.*—In motor-body work, brass and nickel plate are used to a far greater extent than with horsed carriages. Some aver that, as there is no horse to give life and action to the equipage, the use of more bright metal becomes a necessity. The man who has to clean the metal work daily will certainly not agree with this point of view, and here and there are signs that a little more black japan is better, both from an economical and artistic point of view. Plating may be either electro-deposited, when the film is extremely thin and soon wears off, or it may be close-plated, when an actual thin sheet of metal is soldered on. The latter is, although a more expensive process, far more durable, and well worth the extra outlay. Gun-metal and oxidized fittings are sometimes used, especially for interior work, while some of the outside handles may be covered in leather.

*Heraldic Display.*—The final touch, to a well-designed and

finished motor carriage, is the display of a neat cypher, monogram, or heraldic device. A monogram is a combination of two or more letters in which one cannot be separated from the whole, a cypher is merely an interlacing or placing together of two or more letters, being in no way dependent for their parts on any other letter used.

The heraldic device usually takes the form of the owner's crest, and may be in its proper colours or simply in relief, that is of a lighter shade of the body colour. Good herald painters are scarce, and a panel is often marred by an indifferently executed piece of work.

# CHAPTER XI

## *PAINTING*

*The Ideal Paint Shop.*—The cleanest place in the factory should be the paint shop, because dirt here causes more loss of money than in any other department, including the offices. A top light is advisable, because the work is more evenly and strongly lighted, the only disadvantage of skylights being that they generally leak. Cleanliness on the floor and walls is desirable, and all the tools used should be kept in a similar state.

*Ready Prepared Paints.*—The painter should, during his apprenticeship, learn how to grind colours, but it is only the ignorant workman who will refuse the ready-ground colours, which may be obtained from any of the leading paint houses of to-day. Maybe he knows more about the subject than a firm who has devoted a hundred years, much money in special machinery, and fees paid to chemists and others, but it is unlikely. The paint manufacturer should be chosen with caution; long establishment is the chief factor to bear in mind, and a visit to the mills will often increase one's confidence. When purchasing ready-ground colours the painter should be careful to follow the special directions given on the tin. Those ground in japan, as a rule, must only be thinned with turps, and a little linseed oil to retard the drying, but driers have usually to be excluded. Most colours are put up into one to five-pound tins, and in small collapsible tubes.

Time can also be saved by using special brands of filling up. Some of the makers claim that it can be used as quickly as two or three coats a day, and mixed with dry white lead is equivalent to hard stopping.

The body maker, after he has finished his woodwork and superintended the fitting, and himself fixed the ironwork necessary,

hands the body over to the painter. When time is pressing, the preliminary coats of lead colour are put on in the body shop as the job stands by the bench, but it is not a good plan, because any dusting can only be done in a very unsatisfactory manner, as the movements of the men at work, for ever creating shavings and sawdust, and the general state of most body-lofts, render it hardly a fit place even for these initial stages of the painting.

*Dusting the Body.*—The body should be carefully dusted (the corners not being forgotten) inside and out in the body shop, with the rough dusting tool, then removed to the general paint shop, where it can be gone over again with a less worn tool. Perhaps, in a few years' time, the vacuum process will be appreciated, for the usual kind of manual dusting only disturbs the "matter out of place," and not all the dust is transferred to the tool or to the floor, for a considerable portion remains suspended in the air, as can be easily seen on a bright day when sunbeams are present. Dusting should be done with as little flourish as possible and out of the draught. The painter should tactfully point out to the body maker any panel pin not properly punched home or any uneven surface, or framing hammer marks which can be scraped out, or stray excesses of white lead or other fixative used in the joints. He takes it for granted that the timber used is seasoned; if it is not, trouble is ahead, for painting cannot be done properly on any but a dry and non-greasy surface.

*The Priming Coat.*—The body is mounted on a pair of trestles so that it may receive all over, inside and out, top and bottom, a coat of priming or lead-colour consisting of ground genuine white lead, worked up with raw (not boiled) linseed oil, patent dryers or gold size, lamp black to give the mass a tint of grey, and sufficient turps to allow it to be spread by the brush. Turpentine readily evaporates, so that the oil gets slightly in excess as the job progresses, and if the body is a large one, a little more turps may be added as a corrective. Too much oil will cause the coat of colour to contract, making itself evident around pin holes and joints, as well as destroying its absorbing power, which is the chief property of a priming coat. The priming is generally undertaken by the painter's labourer, or even a boy, and it is occasionally looked upon as a very simple job which can be slapped on

anyhow, so long as the surface is covered. Many jobs are spoilt at this initial stage by the labourer having an animated conversation with a fellow workman, consequently the latter part of the coat is finished with less care than the beginning, in order to make up for time lost. The ideal painter will do his utmost to spread an even thin coat (as this will saturate the wood and dry more successfully) over the entire surface, stippling the hairs of the brush well into the pin holes, screw heads, joints and corners of the mouldings, and the skill he thus acquires in spreading an even thin coat will be useful when he is allowed to put on the body colours.

*The next Priming Coats.*—Here comes the first delay. The time required for the first coat to dry is about twenty-four hours, although if more can be allowed so much the better, a fact which holds good at any stage of the painting. If the temperature of the paint shop is kept at 60°–65° F. all the year round, one day will suffice, especially if thin coats, with not too much oil, are used. The next process consists of either one or two coats of a similar nature with twenty-four hour intervals.

*Roof Covering.*—If the body is a brougham, limousine, or other closed body, the roof has to be covered with russet hide, moleskin, or—for a cheap job—linen, to make it stronger, weatherproof, and to hide the panel joints. This is done after the first priming coat, and it is advisable to put a coat of priming on the roof a week before the body woodwork is finished, so that it can be tight and dry before the real painting commences. The covering is sleeked on wet by the trimmer, the top quarter panels being seldom treated as well, as in the old days. This covering should dry tightly and without crease, and receives two or three coats of a mixture of japan, white lead and japan gold size, allowing a day between each coat, this part of the work proceeding simultaneously with the body priming coats, the last coat going over the whole job.

*When Stopping-up is Done.*—Opinion is divided as to when the stopping-up should take place. Some painters do it now, while others leave it till the filling-up, which is next described, is done. The latter method would appear to be the better one, as the five to seven coats of filling-up, if adhering successfully, leave less imperfections to be rectified.

*Filling-up Coats.*—The body has now to receive its several coats

of filling-up, the number of coats differing according to the class of work. Three or four coats are used in cheap work and on metal panels, while seven is the maximum for the best-class jobs with mahogany panels.

The filling-up or rough stuff may be bought ready to mix with the white lead, turpentine, and other ingredients; seldom does the painter now grind his own spruce ochre. Filling-up may also be bought in tins ready to use, all that is required being a little turpentine as a thinner. The filling-up process takes at least a week, for a day should be allowed between each coat.

*Stopping-up.*—When the final coat is dry, the body is stopped up with a mixture of dry white lead kneaded with japan gold-size or hard-drying varnish, to the consistency of dough. Some add turps and tub lead to help the stopper to harden. This hard stopper is forced in carefully with the putty knife in all remaining pin holes and other imperfections showing on the body, but the less need there is for it the better, and the methods of construction should advance along that line which demands less levelling up by the painter. The body has now been covered with a rough reddish or slatey coat, according to the ingredients used, of a stony feel, with white dabs of stopper here and there.

*The Staining Coat.*—The body is then covered completely with a coat of staining or guide colour, consisting of a dark grey thin paint made of turps, gold size and lampblack, or any colour darker than the filling-up.

*Rubbing down.*—This staining coat is called a "guide colour," because it aids the rubber down to see how his work is progressing in the next process. The rubbing down is executed by means of real pumice stone, but more often with manufactured pumice blocks, and plenty of clean cold water. The rubbing down is perhaps one of the most tedious processes that have to be done in the carriage-builder's factory, and there are times when impatience gets the upper hand and back and lower panels get insufficient treatment. The painter rubs with his block, keeping plenty of water on the panel by means of his sponge, and wiping off the sludge as it works up under the process. A sash tool is useful to wipe into the corners with, and the experienced man can tell by the feel with his hand as to how the work is progressing. Theoretically the whole of the

staining coat should be removed, but this is not essential if the surface feels perfectly smooth, and, in fact, American painters sometimes omit the staining coat altogether. Careless and vigorous strokes towards completion of the work will often score the panel. When the rubbing down is completed the body is washed over with clear water and dried with a washleather and allowed not less than 12 hours to dry, although two days is safer, because dampness makes any subsequent coat a total or partial failure, therefore the temperature of the paint loft should be well maintained after the body has been rubbed down and wiped off. The sharp edges of panels, mouldings, and other parts may now be carefully gone over with fine sandpaper, the panel surfaces receiving a similar treatment.

*The Excellence of the Prepared Surface.*—When this is completed the body should feel like a smooth stone slab, and to the initiated this is a fitting opportunity to visit the carriage builder, and note the difference in this surface and that of a body just leaving the bodymaker's hands. He may also with advantage compare it with the office doors and other house painter's work that may be about, and however freshly painted they may be, they will feel very soft after the hardness of the filled-up panel, apart from the fact that the grain of the wood will be showing through. Therein lies the excellence of the carriage painter's work, and it is not too much to say that it is unsurpassed in any other branch of painting work, and maybe is worth all the delay it entails.

*Preparation for the Colour Coat.*—But we are only half-way through with the process; the body has yet to be painted and varnished. Another coat of lead-colour is given, similar to the priming coats described, and faced down lightly with pumice stone and water, but this of course is a light job compared with the previous one of rubbing down. If the rubbing down has not been absolutely successful, some further application of hard stopper may be necessary before facing, but the subsequent coats will be applied with a lighter heart if this is unnecessary. The pigments which will give the body panels their final hue are now dealt with. Small quantities can be ground on the stone with the muller and larger quantities in the mill, but, as has been indicated before, ready-ground paints are available, which are of impalpable fineness if obtained from a reliable

house, and cheaper too, for the dry powder plus vehicles and painter's time is far dearer, besides taking up room and time.

*Ground and Body Colour Coats.*—A coat of ground colour is laid on evenly, the black panels such as the upper quarters and lower rocker parts receiving a coat of black. Then follow two coats of best body colour, and two coats of japan on the black parts, a day being allowed between each coat. Then follows a coat of varnish colour, which, when dry, has to be flatted.

*Flatting.*—Flatting is done with pumice dust, and not with the brick or stone as with rubbing down and facing. Clean cold water is used as before, while a pad of felt is used to rub the dust over the wet panels. The panels being wiped and allowed to properly dry, the body presents that dead smooth surface which has the hardness of the filling made yet smoother and more attractive by the subsequent coats of paint. The final coats of varnish have yet to come, and demand the greatest amount of experience, as no amount of written instruction can ever make up for actual practice. Varnish also plays many tricks which have not all been properly explained, so that all reasonable precautions are necessary to ensure success.

*Varnishing Coats.*—The body, when perfectly dry, is given a coat of flatting varnish and flatted again as already described. The mouldings, if black, are now gone over, and the picking out or fine-lining done. After the final flatting the body is removed to a special varnishing room, kept scrupulously clean, moderately heated, scientifically ventilated, free from strong air currents, and electrically lighted. Here the coat of finishing varnish is applied, during which process this part of the establishment is often locked, and an intruder is looked upon as a person wanting in sympathy with the painter's craft, besides disturbing possible dust and creating cold draughts of air.

*Painting the Chassis.*—Whether the chassis is an old or a new one, there is a lot of cleaning to be done before it is fit for the painter's operations. All grease and dirt has to be removed, and the whole carefully dusted. The chassis is placed on trestles, and the wheels removed. With the chassis painting it will be convenient to reckon in the wings with their stays, painted tool boxes, luggage grids, number plates, and other oddments which the coachbuilder

attaches to the car when finished. The body is mounted on the chassis never later than when the flatting coat of varnish has been dealt with.

*Hard Stopper Plastering and its Dangers.*—The chassis and wheels are given two thin coats of priming colour, after which it is sand-papered down. A thin plastering of hard stopper may then be applied to the woodwork, but as the subsequent papering-down fills the surrounding atmosphere with fine lead dust, a coat of filling-up is much preferable. This coat is then faced down with pumice-stone and water, after which, when dry, another thin coat of lead colour is applied. The colour coats follow, as with the body, the flatting varnish being specially manufactured for the rougher wear the underworks are subjected to, generally known as hard-drying varnish (special motor-wheel varnishes are also made), while the final coat is applied to wings and wheels while away from the chassis, which have been temporarily run on to move the body from the general paint shop to the varnishing room. Certain parts of the chassis, such as the bonnet, where awkward corners are present, may have simply to rely on repeated coats of lead and stopping in order to get up a good surface, because the awkwardness of the corners does not allow of rubbing down or facing to any extent. The inside of the bonnet may receive a coat of lead-colour followed by a coat of black only.

*Finishing in the Varnished Wood.*—The ash mouldings are treated with a coat of linseed oil, which is then carefully wiped off. The panels, which should match as near as possible as regards colour, or some of them may have to be stained, receive six to eight coats of gold-size, allowing a day between each coat to dry. Two coats of flatting varnish next follow, each coat being allowed to dry and flatted respectively with pumice dust and water, and wiped with the washleather and allowed to dry. The final coat of varnish is as with ordinary painted work, except that best elastic varnish is used instead of finishing varnish.

*The Time Occupied.*—The following table expresses concisely the time taken on a properly painted job, after which a few remarks will be made as to quick jobs, and where time may be saved when the job is urgent.

| Name of colour coat and process. | Time occupied. |
|---|---|
| First coat of lead-colour and drying | $1\frac{1}{2}$ days |
| Second ,, ,, ,, | $1\frac{1}{2}$ ,, |
| Third ,, ,, ,, | $1\frac{1}{2}$ ,, |
| Six coats of filling-up and drying | 10 ,, |
| Stopping-up, drying, and staining coat | 3 ,, |
| Rubbing down | 1 ,, |
| Drying after rubbing down | $1\frac{1}{2}$ ,, |
| Coat of lead-colour, any stopping required, drying, and finishing off for ground colour | 2 ,, |
| Ground colour and drying | 2 ,, |
| Two coats of best body colour and drying | 4 ,, |
| One coat of varnish colour and drying | $2\frac{1}{2}$ ,, |
| Flatting and drying | 2 ,, |
| Coat of flatting varnish, and drying | $2\frac{1}{2}$ ,, |
| Flatting, drying, and picking out | 3 ,, |
| One coat of finishing varnish and preliminary drying | 3 ,, |
| Hardening and washing off | 7 ,, |
| | 48 days, or about $8\frac{1}{2}$ weeks of working days, the week ends being thrown in to help the drying |

Such, of course, is an ideal time table, which will ensure a first-class job which will last years of careful driving with an annual touching up, flatting, and revarnishing. The coachbuilder of fifty or sixty years ago often took six months over the painting. But not one motor car in three thousand gets this treatment. By leaving out a coat of lead-colour, two of the filling up, one of the colour coats, hastening all the drying, and leaving out the week of hardening, the time can easily be halved, in this instance, but spread over a period of five or six years the same amount of time is spent in the paint shops, although this may be of little moment if the car changes hands during that period. If no satisfactory method is found of simplifying the painting, it is possible that touring, as distinct from town cars, will merely be painted from the protective point of view, and little attempt made to create mirror-like surfaces. The usual time table is as follows :—

| Name of colour coat or process. | Time occupied. |
|---|---|
| First coat of lead-colour and drying | 1 day |
| Second ,, ,, ,, | 1 ,, |
| Five coats of filling-up and drying | 7 days |
| Stopping-up, drying, and staining | 1 day |
| Rubbing down | 1 ,, |
| Drying after rubbing down | ½ ,, |
| Coat of lead-colour, etc. | 1 ,, |
| Ground colour and drying | 1 ,, |
| Coat of best colour and drying | 1 ,, |
| Flatting and drying | 1 ,, |
| Coat of flatting varnish and drying | 1½ days |
| Flatting, drying, and picking out | 1½ ,, |
| Coat of finishing varnish | 2½ ,, |
| | 21 days, or about 4 weeks of working days |

When plenty of time is taken, a wet day can be avoided for varnishing and as little work done by artificial light as possible.

*A Quick Job with Enamel.*—A quicker job can be effected by substituting for the three coats of body colour and a coat of flatting varnish one or two of a good brand of enamel or lacquer. This will save nearly a week. So far this experiment seems to have been confined to open cars painted a light colour; but these lacquers can be obtained in countless shades. If two coats of lacquer are used, the first of course will be flatted and is usually thinned with turps. No final varnishing coat should be necessary if the lacquer is one of the well-known brands. Such a job can be comfortably got out in three working weeks.

*Repainting Jobs.*—In repainting work, where a job comes in to be done up, the work is only a short process, especially if the same or a darker colour is to be used. When a lighter colour is asked for the old paint has to be removed down to the filling up, although some recommend carefully flatting and giving a coat of filling-up and facing down followed by a coat of lead-colour. It sounds feasible and is worthy of more extended trial. Another method is to touch up the bad places if a metal-panelled body with three parts of raw linseed oil to one of quick-drying varnish, and allow to stand for thirty-six hours, before applying the special light coat of lead-colour. Generally speaking, paint containing white lead should not

be used next to the bare metal surface, but the mixture given above, the same remark of course applying to new work, and often a coat of raw oil, afterwards wiped off, is given to the metal panel.

Some painters do not fill up the panels of metal bodies at all.

*Removing Paint.*—Burning off by means of a lamp is seldom the practice adopted, for there is always the danger of fire among the combustibles surrounding the painter, as well as the unpleasant odour and danger of charring the body and opening the joints. Various preparations are now on the market known as paint removers. One coat of a good brand should loosen the paint, when it can easily be removed with the stripping knife. The burning-off method often means that the filling up is defaced, necessitating another coat or two of rough stuff and subsequent facing to make good, while the use of ammonia and other alkalies is a primitive and costly process, which may mean a great deal of stopping-up to be done before a smooth coat of lead-colour can be got on. In repainting work the preparation of the chassis for the painter is often a long and laborious process, which is not always allowed for in the estimate given. It may be as well to remind the reader that even if a small new panel has to be inserted, a clear fortnight is necessary for painting, if it is to have anything like the character and finish of the other parts of the car.

*Colour Nomenclature.*—In deciding an exact colour scheme for the car, whether the painting or the trimming, a certain amount of difficulty lies in describing a colour. It is always the best plan to have a sample which can be divided or a sample number quoted, as misunderstandings can easily occur. Ask half a dozen people to pick out olive-green from a collection of greens, and the result is simply astounding. Different makers of colour have their own fancy names, and the same name may be a different tint according to the house it comes from. Such descriptions as Napier green, Panhard and Mercédès reds, may refer to any shade according to the individual considered.

*Lining Tools.*—Where a gold or silver line has to be put on instead of the usual line of pigment, this may be done expeditiously by means of a little tool called a gilding wheel. This wheel takes a small roll of paper on which is mounted a thin strip of gold, imitation gold, or aluminium, from $\frac{1}{8}$ in. and upwards wide, according

to requirements. Continuous spools 67 ft. long can be obtained, and it is claimed that this mechanical device is more economical than working from the usual book of leaves. The surface to be treated is painted with gold size in the usual way.

The ordinary lines may also be put in mechanically by a lining machine, which consists of a small square box about $\frac{3}{8}$ in. square and about 2 ins. high, which is used as a pencil. It has below a small wheel on to which the colour from the box flows, in short, like a miniature tennis-lawn marker. By means of a small clip the wheel can be made to follow parallel with the edge of a moulding when a free edge offers itself—a mud-guard being a good instance. Combinations of thin and thick lines may be produced at the same time.

# CHAPTER XII

## *STOVE ENAMELLING AND FRENCH POLISHING*

*Stove Enamelling.*—This process, in which the painted article is subjected to a greater heat than in the varnishing room, is not only a quicker and cheaper process, but it is very useful for those parts affected by heat, such as the engine bonnet (especially the exhaust side), wheel rims, and horizontal surfaces, such as portions of the wings. In the future the carriage builder may do a considerable amount of japanning, or enamelling as it is often called, and what little is done now is usually sent out to cycle enamellers who work for the trade. The specially prepared japan or enamel can be bought ready to use, and the proper temperature it will withstand is, as a rule, stated on the label.

*Preparing the Surface.*—The wing or bonnet has to be dust and grease-proof and quite smooth. Cycle frames are prepared by a preliminary process of sweating by thoroughly rubbing them over with a rag dipped in paraffin or spirits of tar, and stoved for a quarter of an hour at a temperature of 380° F. The motor body builder's articles can be prepared by rubbing them up on an emery bob, which it will easily pay to instal, as it requires but little extra power to drive it, and does the work far more efficiently than by hand. After treatment on this bob, the work is finished off with a cloth and leather bob, which can be fitted on a separate machine or substituted on the spindle for the emery bob. The surface, thus perfectly smooth and clean, is now ready to receive the japan, which may be purchased in almost any colour, and generally has, as a base, resin and shellac with methylated spirits or turpentine. When the work is done on a very large scale, it is dipped in a tank, but this will not be within the purview of the average motor manufacturer.

*The Stove.*—The painted wing is now hung on a hook in the stove, which is usually rectangular, and made of sheet iron, either single or double cased. In the first instance the heat plays directly on the interior, in the second the heat is conveyed to a lining of silicate of cotton or fireclay, which retains the heat and keeps up the temperature of the oven with less waste of heat. The stoves are connected up to the factory gas system, and a larger meter may be necessary if there is a considerable quantity of constant work. A good finish cannot be obtained in brick-built stoves, heated with flues, as they are not only dirt creating, but give vent to sulphurous fumes, which spoil the surface of the work, besides being more expensive to heat.

*The Coats of Enamel.*—The turpentine or methylated spirit is first driven off by the warmth of the stove, leaving a gummy residue which flows owing to the heat present. Black japans are heated to about 300° F., and the more delicate colours to about half that temperature. A coat is stoved for 1½ hours on an average, and care has to be taken to let down the heat gradually, otherwise the enamel may crack. When the job has stood a day, a second coat is applied in the same way, and after a similar interval, a final coat of a special finishing enamel, which has more varnish in its composition than those used in the previous coats, is applied. A first-rate job can be turned out from the bare metal in four or five days, about one quarter of the time asked for in coach painting.

*French Polishing.*—A new department, which has been added to many motor-body building establishments, is that devoted to French polishing, in which are treated the glass frames, tool and accumulator boxes, the underside of roof extensions of limousines and landaulettes, inside folding tables, wind-screen frames, fillets (fixed round the inside edges of the lights) and other items. The work should be done in part of the paint shop, or in a small room which can be kept clean, dry, and warm.

*The Filling-up.*—The woodwork to be treated is glass-papered off with No. 1 paper and dusted off, after which it receives a coat of filling-up made of plaster of Paris as a base, linseed oil or tallow as a spreading medium, and some burnt umber or polish to stain it to the tone required. Rose-pink is also used as a colouring medium for mahogany work, while yellow ochre gives the necessary tint for

ash. This filling-up is rubbed on with a rag and allowed to dry, and if the wood is an open-grained one, such as will occur in a whitewood tool box, the process is repeated. The filling up is glass-papered off, and a coat of raw linseed oil applied, well rubbed in, and the superfluous oil wiped off and allowed to dry thoroughly for at least two days. The coats of polish now follow. This is bought in gallon or half-gallon jars, from which it is poured for use into an old wine bottle which has been properly cleaned and dried. In one is placed some white polish, and in another the polish having the familiar reddish-brown tint.

*The Cotton Rubber.*—The polisher's chief tool is a pad of cotton wool bound in muslin or other clean cotton white rag, the loose ends of which are grasped, and the whole used as a rubber. The polish is not applied to the outside of the rag, but inside to the wool, and allowed to percolate through during the process of rubbing. The preliminary floating coats of polish may be either, say, four alternate rubbings of each kind of polish, or only a coat or two of the white polish towards the end of this first stage. The rubbers are kept in tins, with tightly fitting lids, so that they may be kept moist. The next coat of polish follows with another rubber, after having faced down the first coat with glass-paper. A third rubber is also now required, which is moistened occasionally with a little linseed oil. This oil is used to prevent the polish pad sticking to the work, but only sufficient oil should be used to keep the polish pad moving freely, for any excess will create a want of stability in the final coat which follows. This coat may be repeated for good work, after which the papered and dusted and oil-freed surface is given a very thin and light coat of polish. The oldest rubber, made of the closest woven muslin, makes the best pad for this stage of the work. The polish should only be just damp, which is more easily attained, up to a certain point, when the pad, by continual use, has the pores of the material clogged with extremely fine particles of the solid matter in the polish, and fluffy portions from the wool inside, and from the wear of the muslin cover. As a rule the coats of polish are of shorter duration as they proceed, and a circular motion is indulged in where possible. About 65° F. is the best temperature to work in, and the air should be as dry as possible, which conditions agree with the ideal atmosphere of the paint shop.

# CHAPTER XIII

*WEATHER PROTECTION*

Apart from the fact that the motor car is mechanically propelled, one great difference between it and the horse carriage is a greater provision against the elements, which is necessary owing to the greater speed attained, and the longer journeys undertaken. The main accessories used for this purpose are the many varieties of wind screens, while protection from rain is afforded by cape cart hoods in open cars, and the usual headwork as already used with horsed landaulettes. The chassis is further protected by means of a bonnet and under shield, and in some instances a chain case, while the cleanliness of the body is more or less maintained by wings, dress- splash- or mud-guards. The warmth and comfort of the passengers is enhanced by the provision of doors to all the seats, and the various articles of clothing, rugs and aprons, which have been specially designed for the purpose. In limousines and landaulettes the driving seat is often specially protected by a roof extension canopy.

## Wind Screens

There has been a great deal of attention paid to the design of wind screens during the last few years, and there are several makes on the market, each manufacturer giving a wide range of choice to suit different styles of bodies, and giving varying degrees of protection.

The vital features of a wind screen are the means used to attach it to the dashboard, and the joints provided, whereby the position of the shield may be adjusted.

*Attachment to the Dashboard.*—The usual $\frac{3}{4}$-in. mahogany or other wooden dashboard supplied with the chassis is not always

an ideal foundation on which to erect a heavy glass screen, weighing perhaps 35 lbs., and subject to additional strains beyond its dead weight in the shape of resisting the force of the wind when the car is travelling rapidly, and having to support much of the weight beyond the central line of support. Therefore the dashboard supplied should be carefully examined as to its soundness. The scuttle type of dash being framed up with at least 1-in. stuff (probably ash), the question of safety does not apply in this instance, as the flaps of the wind-shield bracket can easily be arranged to be bolted through the framework. There is no need to weaken the dash by bolting on separate dash-lamp brackets, as wind-shield brackets may easily be obtained in which lamp brackets are incorporated. The centres of the two socket bearings should not be less than 8 ins. apart vertically, and the bottom of the stanchions should have a tight sliding fit, in order to eliminate rattling as much as possible and to give a firm hold. Further safety may be gained by screwing on a stay to the bottom half frame, when a heavy inclined shield is used, which stay is secured at its bottom end to a fitting screwed to the bottom framing or the body bracket. If the lower half of the wind shield is adjustable, then a telescopic stay will be required.

*Varieties Used.*—The various varieties of wind shields may be summarized as follows :—

(*a*) Half screen, either vertical or inclined backwards, with or without an upward curved lip at the top.

(*b*) As above, but adjustable.

(*c*) Full single-jointed screen, fixed straight lower portion with top half adjustable from centre of screen only.

(*d*) Full double-jointed screen as above, but with top half adjustable from centre, and also independently, with or without top attachment for cape cart hood, or wooden or leather roof canopy extension of a limousine, landaulette or cabriolet.

(*e*) Full single-jointed screen, fixed backward inclined lower portion with top half variations as (*c*) and (*d*).

(*f*) Full triple-jointed screen with adjustment to lower half, and top half adjustment as (*d*).

(*g*) Full screen as (*c*) to (*f*), with additional deflector screen, that is, a short frame, inclined upwards and forward to divert the

air currents away from the narrow opening left between it, and the edge of the top inclined half of the screen, thereby providing an undisturbed gap for the driver to look through.

(*h*) Torpedo screen, which generally swings from the top of a pair of short stanchions. A full screen may be used if the scuttle dash is low, and deflector frames are also fitted.

(*i*) Detachable screen, a type used with closed bodies having a roof extension. The stanchions are separable at the centre, the junction being neatly hidden when the top half is removed, by means of a brass acorn screwed into the top of the lower half of the tubes. The screen may also be a double or triple type as used with open cars.

*The Function of a Screen.*—The object of a wind screen is to protect the face and person from the full force of the contact with the air, and in closed bodies the front windows should be kept open as much as possible, so as to prevent back draughts. A wind screen should shed the rain rapidly, and various appliances can now be fitted so that the glass can be wiped without the driver having to leave his seat.

*Details of the Construction.*—The frame of the shield may be made of mahogany, walnut, maple, cherry or other suitable timber. The stiles, or sides of the frame, are usually $\frac{3}{4}$ in. thick to coincide with the half-round or other standards used, and it is seldom necessary to make the stiles more than $1\frac{3}{4}$ ins. wide. Top stiles are often only $1\frac{1}{4}$ ins., while the side stiles of the top half, which are made to swing, may be $1\frac{1}{8}$ ins. to give clearance for swinging. The frame is kept as light as possible merely for appearance' sake, for glass is heavy although it does not give one that impression. The normal width of screen is 3 ft. 6 ins., which is satisfactory so long as it has nothing wider than this to protect, but with the fashion for flush-sided bodies having enclosed levers, a 4-ft. screen is not an inch wider than necessary.

With the full screen the centre wooden stiles may now be regarded as obsolete. The half screen, when it has no fourth stile to hold the glass securely at the top or bottom, as the case may be, should have the side stiles framed slightly taper so that the two free ends of the side stiles, when framed to the bottom stile, have a greater tendency to grip the ends of the exposed edge

of glass. The top half, although without a bottom stile, is now by leading makers fitted with a piece of brass channel which acts as a safeguard should other attachments fail. The frame may be further strengthened by screwing on round the edges a half-round brass moulding and using neat corner plates, and whenever a screen folds on to another part, neat rubber buffers should be fastened. The glass, which should be $\frac{3}{16}$ in. plate, is bedded in felt or rubber. Some wind shield fittings are made of cast brass, but the more reliable material—wrought iron—is, of course, by far the best, and may be nickel or brass-plated as desired.

The frames are usually french-polished, but they may be varnished as described under "finishing in the natural wood" (see p. 118). So far, few motorists care to have them painted to match the body, while on the other hand a light appearance is gained by using all metal frames. Apart from the thickness and condition of the dashboard, its width and shape are also factors to be considered when mounting a wind shield. If it is narrow, the wind-shield brackets will have to be cranked if the dashboard is not built up in any way, while if any fancy outline is used to the top, the bottom or filler board or separate board immediately below the bottom stile will have to be cut to shape, and if the curve is quick this will mean cutting into a wide piece of timber. The wind shield, in the opinion of Messrs. Auster, should not rest on this bottom board, which is only used as a make-up piece between the shield and dashboard. About $\frac{3}{16}$ in. clearance should be left which will prevent chattering, and the support of the screen may be safely left to the brackets and other fittings.

Regarding the height of the screen, this will be so arranged that the top of the lower half may be looked over, while the top half will vary somewhat according to the style of body. The fact that one looks over the lower half has suggested to some users that a heavy glazed frame with its attendant expense and danger is often unnecessary, so that a light wooden canvas or similar panel can be substituted. It must be remembered, however, that a view of the front wings is often obtained through the lower half of the screen, a matter of some importance in judging width when driving in heavy traffic. A half shield made of aluminium can be obtained which weighs less than 14 lbs. Those who are

afraid of cuts arising from broken glass can have the frames fitted with $\frac{1}{4}$ in. wired glass in which the wire mesh is embedded, also wire gauze, of about 40 mesh to the inch, may be used by itself, but neither gives such a clear view as plain glass, while the gauze is not waterproof at high speeds, and is apt to mislead the chauffeur when driving at night. Bevelled and curved glasses also distort the rays of light.

*Wind Screen Joints.*—The most important feature of an adjustable screen, and this type is the one which predominates, is the design of joint used. This should give as many variations of position as possible, so that it may be regulated to suit the height of the driver. The expanding and contracting brake type of joint gives practically universal adjustment, while the toothed type gives a solid and positive locking at as many positions as there are teeth in the joint. Some American screens work on hydraulic principles, in which a piston works in a cylinder filled with oil as the shield is moved, and this pattern has also a universal adjustment. Worm gearing is also used and has been found most satisfactory. It is a decided advantage if the adjustment can be made from one side, or from a central handle or pedal.

A wind shield absorbs by its resistance to the air an appreciable amount of the total horsepower transmitted to the road wheels. When the lower half of a wind shield folds downwards it should be designed so that it misses the steering wheel, otherwise a foreshortening arrangement will have to be used, or provision made for the shield to fold over forwards.

With a backward inclined screen extra strength is required in the side fittings at the angle made with the vertical.

The triple-jointed screen is a popular type now on the market. The lower half is adjusted slanting towards the driver, so that the wind is directed over his head, while the upper half is swung forwards so that he can see between the opening of the two halves.

In order to reduce wind resistance, shields have been made inclined at a vertical angle, so that the two half screens meet in a forward peak.

Limousine shields, so far as the top half is concerned, may be adjusted by various simple means when the top half merely opens

outwards. The adjustment may consist of a small collar sliding on the stanchion attached to a metal arm, or the socket may be on the arm itself. Quadrants of various patterns are also used for joints of all types of screens.

*Screens for the Hind Seat.*—Wind shields for the back seat may consist of a flat or curved shield fixed to the framework at the back of the driving seat or the Auster adjustable extending pattern complete with knee aprons, which can be drawn closely to the hind seat and used as a table also when required. A back seat screen may also be fitted to lie on the door as with a front scuttle-dash screen.

## Cape Cart Hoods

The cape cart hood is by no means novel, having been utilized even in the double extension type on American horsed vehicles for at least twenty years. The modern type as applied to motor cars has been perfected in many details, a notable instance being the control of a large double hood by a single pair of hands.

*Single Hoods.*—The hood as applied to the two-seater has several little problems of its own. Head room may be reckoned as 4 ft. from the seatboard to under the crown of the highest stick, and the rise of the hood horizontally as 6 ins. The back stick should sail out so that the top is at least $1\frac{1}{2}$ ins. beyond the square line of the back of the seat, and the length of the hood will be governed by the position of the top half of the glass screen, for the peak of the hood should extend in front of the glass at least 7 ins.

A cape hood consists of bent wood (generally ash) sticks or bows screwed to neck plates or fingers which turn on a fitting called a body prop, which is securely fastened to the framework of the body, and often, to give better purchase, is extended downwards to the seat. The number of sticks should not exceed three vertical ones, and the front one should be as much out of the gangway as possible. A fourth and horizontal stick supports the waterproof covering over the gangway, and forward to keep the glass screen as free as possible from rain, so that the driver may see clearly through it under all conditions of weather. This stick is attached

by a special extension fitting which allows it to slide on or fold over the front upright stick, and also to be locked in position when the hood is extended.

The body prop centre is decided by the position which gives as near as possible an equal length to the upright sticks, and at the same time allows the one with the shortest radius to clear properly the back rest of the seat. The front horizontal stick slides or folds on the front vertical one so that the hood is shortened as much as possible when down. When a third seat is fitted at the rear in a small car, there are various means by which the folding of the hood may be kept within limits, a good plan being to slide a short stick each side of a central vertical one. If side curtains are used, it is important to remember that a side light is a legal necessity in some quarters, especially the Metropolitan police area, and curtains which may be attached from the inside are more convenient than if one has to step out of the car and button them on.

The single hood, that is one operating from one pair of centres, may be fitted to a side-entrance phaeton, but the strain on the fore-structure means that in time it may become weakened.

*Double Extension Hoods.*—As there is more room in which to set out the front sticks of a double hood, the obstruction of the front gangway is a problem which has seldom to be confronted. The main entrance, however, has to be watched, but seldom is there any excuse for anything but a free headway. The normal length of a four or five-seated phaeton should not entail the use of more than four upright sticks with a horizontal one for the peak. A hood looks well balanced when the two centre sticks are vertical, and the first and fourth incline in opposite directions at equal angles. The sticks should be set out, however, to support the fabric at equal distances rather than to strive at any precise geometrical arrangement, the capable designer doing his best to incorporate the two considerations as much as possible.

The back stick will sail out from the square line as with a single hood, and the two middle sticks must be clear of the gangway. The width over the front props must be the same as the hind ones, which will be in relation to the greatest width of the body, so that the whole can be folded down from the hind props and clear the body

panels. Another method is to have shorter overhanging props, and to crank out the fingers attached to the slats.

If a body is longer than usual an extra stick may be used at the rear; the use of three sticks in the front portion is seldom necessary, as even with greater distances between the dashboard and the front of the driving seat this is compromised by the backward rake of the wind shield, so that within a little the protection to be afforded in all types of bodies to the front seats is practically the same as regards length. Sticks may be 3 feet apart at the top without any undue sagging in a well-strained hood.

*The Fittings.*—The fingers which secure the sticks to the body are generally attached to the outside of the stick, so as to give a decorative effect, which may be further enhanced, for those who are fond of plenty of metalwork about the car, by the use of double shell joints, in which plates are screwed both back and front of the stick, the inside set of plates being merely screwed on, and not attached in any way to the main turning centre. A similar effect is gained by the use of tubular fittings.

The two-stick joint has usually the outside plate hinged and cranked at the lower end to the inside straight one. Sometimes a third plate may be hinged to the next one, but the less centres in the design the better. The front fitting is supplied with a butterfly nut, or other device, so that it may be easily detached from the front props after the nut or other fastening has been loosened.

At the rear the hood joint is provided with an ear into which the spindle of the front joint is inserted when the hood is lowered. Apart from a hind centre there is a third prop well flapped to the elbow of the body, which forms the resting-place of the hood when down, and it must be long enough to take the full width of the hood. All the six body props are usually cranked into sockets and retained by nuts, so that when required the hood may be entirely removed. The height of the hood-rest will also decide the angle of the hood when down. The sticks of the hood should be provided with separators which will keep the sticks apart when down, and these separators should be made so that the sticks are held firmly as well as kept apart. The whole set of sticks may be strapped to the prop through a neat slot in the prop, or a special clip may be used, while the bed of the prop should be padded with leather or

rubber. A cover to slip on should be provided so as to keep the fabric of the hood clean, as one of the duties of a hood, especially when down, is to act as a dust screen, which it generally does effectually.

*The Covering and its Fixing.*—The mohair, cashmere, twill, or other waterproof material is laid on the sticks in three portions—a central piece lying on the flat horizontal portion of the bows, and two side vertical pieces, the sticks being kept apart at their proper distances by means of webbing nailed on. The top flat piece of twill overlaps the side pieces about 1½ ins., and the bottom edge of the side pieces is turned over and hemmed, and strengthened by a leather binding. The back curtain extends from the junction of the side pieces with the back stick, and is in one piece, cut out after sewing in the back light, and hemmed and bound as before. The webbing running from the tops of the bows is brought down to the top of the back panel, doubled over, and fastened to a pair of turn-buttons which hold the ends, and the back curtain as well. The fabric of the hood is held to the sticks by means of brass rose head screws and washers, and usually a piece of beading is used instead on the hind stick, a method also adopted for retaining the valence on the front extension stick. The front retaining straps are fastened to the inside of this stick by screws and washers. Brass beading is sometimes used as a decoration and means of fastening to all the sticks, and in a few cases the bows may be strengthened on the front edge with light iron half-round plates.

*The Means for Keeping the Hood Open.*—Outside joints, in many cases, extend from the front stick to the hind body prop. In a four-stick head there will be top props screwed to the first three sticks, which provide bearings for each of the joint ends. The second and third top props will differ from the first or front one in having a longer neck, as they have to each carry two joint ends. Between each pair of joint ends a knuckle joint is welded in to the required length, so that when the head is collapsed, the 6 ft. or so of ironwork each side may be snugly folded down by the side of the set of sticks, and when the hood is up these knuckles lock it into position. In either a single or double extension hood the plotting out of the knuckle joints requires a little planning out in order that the knuckles, when hinged right back, shall cause each pair of joint

ends to lie at the right angle, and when up, shall be slightly eccentric so as to form a "snap" fit.

Theoretically, the outside joints should keep the set of bows taut, but they are seldom relied upon to do this unaided. They are made much lighter than the patterns fitted to leather hoods, and considering the length, width, and height of many of the superstructures carried on open cars, it is more economical both in weight and cost to provide a pair of front straps (or, better still, neat wire ropes with strap ends which will not stretch nearly so much), which are fastened to the chassis front spring dumbs, or to staples rivetted into one of the flaps of the front wing stays. If the back straps are used in addition to the webbing, it should be possible to dispense with the first and last pair of joints. The hood is also fastened in many cases to the top of the wind-screen, either by short straps, a narrow curtain, or a locking arrangement between the bow and the frame of the shield.

A handsome, though naturally a more expensive finish, is obtained by means of a leather covering in lieu of the waterproof twill. Double enamelled leather is also used, which has the outside finished black, and the inside to match the trimming, but this material is liable "to bag" after its first stretching on the sticks. Such a covering is easily cleaned, and those who attempt to clean waterproof twills with petrol should remember that the rubber on which the material depends for its waterproofing dissolves in that liquid.

"*One-man Hoods.*"—There are already some six or seven "one-man" hoods now before the motoring world, all more or less easily manipulated from one side at a time, or in front by a single pair of hands. The lazy tongs principle is the prevailing principle in some; in others, the front portion slides down the front stick of the hind portion. Considering the slightly increased cost, the motorist is well advised to have a good pattern of one-man hood fitted, bearing in mind the advantages gained, and the trifling additional complication necessary for their working.

*Divisible Hoods.*—Another type of hood is that which is divisible, so that the front and hind seats may be protected independently. This may be brought about by the use of two separate hoods, or the covering is made to unbutton in the centre, and a drop curtain is

provided behind the front seat, an accessory which is often added to the normal type of double extension hood. These separate hoods may be useful when a fair amount of driving is done with the back portion empty, but, then, that is perhaps a proof that a two-seated car should have been ordered in the first instance. The divided hood is also used when the hind part of the body is detachable.

*Curtains.*—Side curtains are not always included in the price of a cheap hood, so that when paying less than £15 for the covering of a car, it is as well to know of what the specification consists. Curtains are a comfort on a wet and windy day, but they cannot by any means be considered an ornament. The top and bottom of each curtain should be well hemmed and bound with leather, and will be fastened by turn-buttons, and should well cover the door opening, and allow of easy entrance and exit, the same remark applying to the front gangway. Celluloid lights should be as small as possible, as the larger the light the sooner it will crack, and look shabby if the curtains are rolled up.

Vital fastenings, such as prop nuts, butterfly nuts, and turn-buttons (with screws to fit), should be carried as spares, as a lost one may mean a useless hood. Probably, in the future, more of these fastenings will be provided with lock nuts, or split pins, so as to obviate any anxiety in this direction.

For hot countries the cape cart hood with rubber interlined fabric is hardly suitable as a sunshade. Either a lighter material should be used, or a sunshade fitted much after the style as is sometimes seen attached to a lady's driving phaeton. If the shade is red underneath, it is said that the protection from the sun is rendered more effective.

## Wings

There is room for improvement in the majority of wings or mudguards fitted to motor cars, and future designs should be constructed more with the purpose in view of keeping mud from coming in contact with the body and chassis, also from the other vehicles and users of the road, and less for ornamental purposes. The wings of the horse-drawn carriage are not strictly an addition

for usefulness only, for in many instances advantage is taken of graceful outline and highly polished surface to increase the beautiful appearance of the equipage, and it is owing to the fact that these styles have been largely adopted without sufficient modification that one hears so much grumbling on the part of the motorist that the mudguards fulfil their function but indifferently.

Wings may be constructed of sheet iron or steel, of wood, or a wrought-iron frame covered with patent leather top and bottom. Aluminium was used to a considerable extent for this purpose when that metal was at the height of its popularity as a panel material, but experience has shown that it wears badly at the bolt holes where the wing stay flaps are fastened, and at any other point where there is likely to be vibration, or a continued strain.

Wooden wings made of birch or walnut, although found satisfactory under the less arduous conditions of horsed-carriage work, in private car work have been found liable to split unless scientifically stayed, and only the best selected timber used. Low cost and weight are two great assets with the wood wing.

*Flanges and Side Guards.*—The most popular type of wing is the one made of sheet steel, generally of the lead-coated variety; is cut, bent, and hand-hammered to the required shape, and any swaging or moulding required produced by rolling the wing in a special machine. The edges are strengthened by binding the edge round a stout iron wire. Modern types are provided with a flanged edge forming a lip from 1 in. to 2 ins. deep, so that the mud-retaining properties of the wing are increased. In addition, side guards between the inside of the wing and chassis are usually fitted, which may be rivetted on, like the flange, or else hammered in the one piece. With inside guards some loss of accessibility to the oil and grease caps of the springs, axles, and brake adjustments may be experienced, and if this is found to be excessive small inspection doors should be fitted. Care has also to be taken to ensure that the full locking of the front stub axles is not interfered with.

*Mud Streams.*—Efficient mudguards can only be constructed when designers appreciate to the full extent how the mud streams are created, and what path they are most likely to travel in as the vehicle moves along. The front wheels have a wider range of

mud-throwing owing to the various angles which they take up under the influence of the steering wheel. When they are running parallel with the longitudinal axis of the car, a spray of mud is being thrown off tangentially at all points of the circumference of the wheel and at the point of contact mud is being forced out sideways and upwards in small showers on each side, more or less at right angles to the direction of the car's travel.

The first-mentioned streams of mud may be caught by having a wide wing with a $1\frac{1}{2}$ ins. flange all round the edge facing the onlooker, and round the front and back until it meets the side guard. Apart from this, a leather weighted flap, the same width as the wing, should hang down from the lower extremity of the wing so that only 4 ins. clearance is left between this flap and the ground. A leather flap is safer than a stiff metal one when the road clearance is so small. In front the wing should follow the shape of the wheel to about 1 in. beyond the line drawn at right angles to the ground line touching the front of the tyre. The wing should be as wide and the flanges as deep as possible without offending the artistic susceptibilities of the owner. Possibly in the future, with wider tracks, it will be practicable to allow the wings to move with the front stub axles.

As the car proceeds along the road, the radiator and spokes of the wheels cut up the air currents met with and also those produced by the car's forward motion, giving a large number of diverging currents, so that the more generous the front opposing surface of the wings the less chance there is of the wind currents bespattering the car. The air currents which the car meets rather than those which it creates are the more difficult to allow for. The side stream of mud produced at the contact of the wheels with the road can be effectually intercepted by means of a splashguard, which consists of a valence of skirt of interwoven spirals of wire hung on a metal frame which is mounted on bearings fixed to the axle cap of the wheel. This arrangement could be attached on each side of the wheel, in order to intercept the mud streams on either side, but would no doubt be considered unsightly on a private car.

Flanges on the wings also prevent, to a large extent, the mud being blown off the guards on to the body panels beyond.

The hind wheels are always in the same relation to the chassis,

so that the direction of the mud streams may be anticipated with a fair amount of exactness. The front of the wheel is also better protected, as the hind wings have also to perform the office of dress guards to the main entrance, so that the windage of the car is not a serious matter to be contended with. The outline of the wings should follow round with the shape of the tyre to about 3 ins. beyond the centre of the wheel, and side guards should be provided, especially if the body is kept well within the wheel base, and the wheels are well beyond the side surfaces of the body. This is more important with small cars, where a hind seat may be quickly covered in mud if this attachment is not provided.

Motor body builders have been slow to adopt the effective cycle mudguard pattern, for the dome-shaped guard cannot be said to be fitted to the majority of cars. It is graceful in appearance, presents a highly reflective surface for the varnish, and is more handsome than a flat wing with a square flanged edge. The time will not be far distant, perhaps, when designers will be able to attach the wings directly to the axle arm as in a cycle, or a similar way, so that the necessary clearance may be reduced to a minimum.

*Detachable Wings.*—Already wings are made detachable, as the best type of mudguard, by reason of its close association with the tyre, is necessarily badly placed for tyre removal. The prevailing type of detachable wing is seen at its best when one nut and one socket controls both stays. A pattern where only the wing is detached and the stays left provides an element of danger to the tyre remover as well as giving very little extra accessibility. Wings with fixed side guards must, of course, lift in order to be detached from the car.

Side shields are seldom brought forward far enough in front, the excuse being that the lamps are interfered with, but it would be a better plan to keep the body as clean as possible by efficient side guards and mount the lamps on the top of the wings by a bracket forged to a reinforced wing stay. When Stepney wheels are being used, an extra width of canvas mudguard can easily be arranged to clip on to the permanent portion. The present types of wings add to the wind resistance of the car, so that one has largely to choose between dirt and pace.

## Step Guards

Every modern car is also fitted with guards between the back edge of the long side step and the side member of the chassis. If this is made of sheet steel, it can be finished off more neatly than any expensive array of patent leather, which in a short space of time will sag and buckle and present a surface of countless broken reflections, but the metal shield is said by some to be a noisy accessory and also a bar to accessibility.

The wings and steps by their proper design and additional guards should leave little work for the undershield to do.

## Undershields

The undershield may be pressed out in one piece with the side members of the frame, or may be attached to suitable lugs provided and fastened by fly nuts so as to be easily disengaged. The tendency of engine, clutch, gearbox and transmission design to-day is towards enclosing the moving parts more, so that little is really exposed which might be easily injured by flying grit and mud. This is particularly the case with the unit type of construction. The shield seldom extends further back than the gear-box, and if well designed should prevent dust-raising to a large extent, and when the fan is incorporated in the flywheel its close fitting becomes a necessity, so that all air is properly drawn through the radiator.

## Bonnets

The bonnet is an important weather shield, and is made of sheet steel resting on suitable flanges behind the radiator, and in front of the dashboard. Most types hinge upwards each side from a central rod, and the whole can be removed when a prolonged inspection of the engine is necessary. Louvres or ventilators have disappeared to a large extent from bonnets now, and with modern cooling systems it becomes necessary, for the efficient working of the fan, to make the bonnet as airtight as possible. With a dashboard radiator, the

more graceful Renault and C.G.V. style is being revived, which is hinged on the top edge by the dashboard, so that an upward swing immediately exposes the whole engine. A felt or leather pad should be provided for the bottom flange to rest on, so as to reduce noise as much as possible, and a hinged stay should be provided with the Renault type to keep it erect when open.

The shape of the bonnet goes a long way towards expressing the individuality of the car, but nowadays differences are more minute, and it becomes more difficult every day for one to distinguish between the various makes of cars from this part of the car alone.

A large bonnet does not necessarily conceal a powerful engine; sometimes it is provided to give that impression; still this type of vanity has its compensations since increased engine accessibility is obtained.

## Chain-cases

Chain-cases, owing to the unpopularity of the chain-driven car, even for public service work now, are seldom found on new cars. Should the motorist have a Mercédès, Berliet, or Delaunay Belleville, he may purchase a chain-case much on the lines of the cycle pattern, made in two halves, and easily fitted, and so arranged that the chain always runs in a small bath of oil, making the running of the chain and sprocket silent and smooth. Lubrication should be possible without having to unfasten any inspection door.

## Body Design and Weather Protection

The design of the body itself is the main factor in weather protection. The higher the sides of the body, especially the front portions, the cosier the seats will be, although the body may form, if not ventilated, a trap for warm petrol-flavoured air issuing from between the floor boards.

It is only during the last three or four years that doors of any height have been fitted to the driving seat. The fully enclosed car is the last word in weather protection, and unless the driver is able to get a good look-out on all sides, and does not shut all

the windows and ventilators so as to be able to hear approaching traffic, there is an element of danger in the isolation so afforded.

## Clothing

The remaining means of protection from the elements is the special varieties of clothing provided. Wind screens have done away with the need for unsightly goggles, and all who ride in closed cars do not require to be dressed in any particular way. The majority of motorists have a decided preference for fresh air and consequently open cars, and when one is moving along the road at twenty miles per hour on a cold day against a head wind, or on a dry summer day on a dusty road, extra clothing of some kind is necessary to protect one against cold air or dust, as the case may be, which by reason of the prolonged high speed, are driven against the body with far more force and persistence, and therefore power of penetration, than with slower forms of traction.

The ideal garment gives protection from wet, wind, and dust with a minimum of weight and effective ventilation. The ordinary mackintosh does not satisfy these requirements, neither does a heavy, thick, fur-lined coat. Materials can now be obtained which are proved in the weaving and will withstand considerable variations in temperature without injury. The stuff being self-ventilating, the garment can be worn at all times without discomfort. Motor clothing for rough weather requires a closely fitting collar, and many prefer an overall which can be slipped over the head so that there are no front openings to let the wet in, but this again can be combated by ingenious systems of double and side buttoning. Headgear should be supple and close-fitting, and gloves of the gauntlet type are preferable in windy weather. If an apron be used, this should be properly shaped so that it falls naturally between the legs and gives comfort in working the pedals.

Clothing for ladies will follow along similar lines, although more latitude will be given for decorative effect. Collars and cuffs will be in contrast, obtained by using a different colour, or the same colour in a material of different texture. The range of

linings and trimmings will naturally be a wide one. Full protection is required for the dress underneath, while the outer coat should be easily slipped off, so that a dainty appearance may soon be obtained when paying calls. The ingenuity of the motor milliner has placed before the lady motorist many styles of neat headgear, which do not easily spoil in wind or rain, while the veil is an indispensable item and is often used in conjunction with ordinary headgear. Muffs should be of leather or other material not easily spotted by the rain, and if the lady is a driver flat heels should be found on her boots or shoes.

# CHAPTER XIV

## *INTERIOR ILLUMINATION*

*Roof Lamps.*—The high-class limousine or landaulette body is always furnished with some scheme of interior electric lighting, as these types of cars do a considerable amount of evening work. A specially flat and neat type of roof lamp has been designed which can be let into and screwed to the wooden framework of the folding head, or some convenient part of the fixed roof. The back framing in limousine bodies is also utilized for lamp fixing, and has the advantage of throwing the light over the shoulders of the passengers, should they desire to read, while bodies with cape cart hoods have special lamps attached to the bows of the hood. The amount of light available is from two candle power and upwards. A four-volt lamp, or lamps, giving four candle-power, is ample considering the floor area of the car, and equals the amount of illumination generally provided in a medium-sized room. If one lamp only is used this will be placed centrally overhead, and as far back as possible; two lamps can be placed equidistant overhead, or in each corner of the back of a limousine; three lamps may be considered the maximum, one being set out centrally overhead, and two in the back panel as before mentioned. The metallic filament lamp is now available for all classes of motor lamps, and together with the carbon filament patterns, throws a minimum of shadow. Motor lamps having to undergo a certain amount of vibration should have the delicate filaments well supported. The lamps fixed in the roof are made flat and furnished with a nickel front to match the other furniture and fittings used inside, or they can be had in various colours to match the upholstery. The lamps for the back panel are adapted to the rounded or angular position which they are called upon to occupy. A strong light may be more economically

obtained by using two small bulbs of equal power in one lamp. The front of the lamp should be removable by the unloosening of two screws, so that the filament when burnt out can be readily replaced by a fresh bulb. Spares of this character, if carried on the car, should be kept snugly in small boxes well lined with cotton wool, or similar substance. When touring a new bulb of the exact size is not always easy to purchase without delay. The motorist in most cases leaves the coachbuilder to arrange the lamps, but if not their position must be decided before the trimming starts.

*Wiring.*—The wiring of the lamps will be hidden, as much as possible, and let into the pillars and other parts where convenient, so as to make a neat job. The switches should be handy, generally somewhere on the elbow towards the door, and arranged to control one or a set of lamps as desired. If the body has a detachable top, the wiring system will entail the use of a plug (a neat two-pin ebonite type being usually adopted), so that the upper wiring may be disconnected on the side (usually the off) which the wiring is run up, or a single-pin or pole plug may be used on either side, as an alternative.

*Lighting Accumulators.*—The source of power will be an accumulator corresponding in voltage to the greatest individual lamp voltage, and of amperage according to the number of hours' light desired without recharging. Accumulators are heavy accessories, but it is economical to have as large a one as possible. A 4-volt accumulator measures 9 ins. by $5\frac{1}{2}$ ins. by $8\frac{1}{2}$ ins. and will light three 4-candle-power lamps (about the same voltage and 0·5 to 0·9 amperage) for twenty hours. An accumulator should always be discharged with plenty of margin, and in this particular instance the accumulator will be recharged at least fifty times before a set of reliable lamps will be burnt out, for a good brand should last 1000 hours.

The capacity of an accumulator depends on the particular make, and the area of the plates, counting both sides, a rough estimate being 1 ampere per 14 sq. ins. of positive plate. The discharge rate, that is, so many amperes per hour, is another important factor, and will be stated on the accumulator label. The total amperage of the battery divided by the discharge rate will give the number of hours it may be used. Experiment shows that the capacity

increases as the discharge decreases, that is to say, that if the output is lessened the capacity increases beyond the proportional advantage at once apparent, also less amperage is given out than has to be charged up when renewing the accumulators, the average difference being about 25 per cent. to 30 per cent.

If a lamp is worked at a higher voltage (overloaded) than its stated capacity, it absorbs more watts (amperage × volts), and gives increased illumination, but at the expense of the life of the lamp. Working a lamp below its normal capacity has an opposite effect.

It is useful to remember that lamp bulbs burn economically at an efficiency of 1 watt per candle, so that a 60 ampere 4 volt accumulator, capable of an output of 240 watts, will light two 4-volt 4-candle-power lamps for 30 hours, but this is on the safe side, as a 4-volt 0·6 ampere, festoon bulb Osram metallic filament lamp will usually be listed at 3-candle-power and not $4 \times 0{\cdot}6 = 2{\cdot}4$.

The sizes of accumulators vary according to the maker, but as the area of the plates and their number decide the amperage, the cubical content is the safest comparison to make, if efficiency is studied from the point of room taken up.

Regarding the position of the accumulator, it would appear, on the face of it, to be the simplest plan to carry it in the hind locker under the seat, with a neat wooden guard screwed to the floor, so as to keep it fast in its proper position, and to prevent breakage of the leads or wires as well as injury to the accumulator and its connections.

The body, so fitted, when detached takes all its wiring with it, but it has been recommended, by Messrs. C. A. Vandervell, that the long side step is a better position for the accumulator in its waterproof box. In this case a two-pin plug is used between chassis and body at a point near the bottom of the door. As the wiring passing from the body is more exposed than in the system first described it should be further protected by passing it through rubber tubing, although brass or copper is preferable if the tubing is likely to come in contact with grease or petrol. In some cases the exterior lamps are wired from the same accumulator as the interior ones, while independent circuits are a safeguard should a lamp fail unexpectedly.

## Exterior Illumination

*Legal Requirements.*—Outside lamps are a legal necessity. One must have at least one lamp on the extreme right of the car; if it is used to show a rear light as well, the back number must be illuminated between one hour after sunset and one hour before sunrise, and the headlights must not be searchlights capable of being *independently* swivelled without relation to the direction in which the car is proceeding. With taxicabs, the dial of the taximeter must be illuminated within the limits of the lighting-up time. Motor omnibuses must have an inside light if they are used for public service in London. For appearance' sake, it is usual to carry a pair of dashboard lamps, and when on their brackets they should approximately define the greatest width of the car.

The position of the headlamps should interfere as little as possible with the radiator cooling surface, and be free from the path of the starting handle when it is revolved. The average height to place headlights from the ground is about 3 ft., while greater heights, giving a larger forward range of illumination, can be obtained satisfactorily by placing them on the front wings, which have been provided with specially strong stays for the purpose.

One or two headlights are necessary when much country driving is done, and in town are a safeguard in moving through slower and often (in the absence of equity in vehicle law) unlighted traffic. The lamps may also be placed on brackets forged to a hinged rod which is swung open when starting the car, but this complexity is usually unnecessary.

Pillar lamps, fastened to the front standing pillar, may be used in addition to or in lieu of the dash lamps, and look well on a town car, giving the effect somewhat of a horsed carriage. The tail lamp will be placed on the off side for British touring, and on the near side for American and Continental road travel, owing to differences in the rule of the road.

*Electric Lamps.*—Headlights will be either 8 or 12 volts. and provided with suitable plugs so that they may be disconnected from the wiring system when necessary. Useful neat side lamps will be rated at 4 volts, and the tail lamp of similar capacity. The clear burning, non-blow-out electric tail lamp is obviously an advantage

over an oil lamp, and besides which a tell-tale device can easily be arranged in conjunction with a simple fitting on the dashboard. Sometimes the number plate is designed as a neat illuminated sign, especially with electric cars. The square-shaped type of dash or pillar lamp makes an elegant finish to a town car. Modern patterns are designed with the contact fitting under the bracket, so that it is practically unnoticeable.

Any type of lamp may be provided with waterproof detachable covers for use in the daytime when the owner considers lamp-polishing labour before the smart appearance of his car.

Another exterior lamp often used is the pillar lamp clipped to the steering column for reading the speedometer, mileage recorder, oil and petrol gauges and so on at night. This should have a universal movement, and may be in circuit with the tail lamp, so that it will immediately tell the driver if his back light has failed. This pillar lamp may also be detachable for road inspection purposes. A fixed lamp screwed to the dashboard may be had at one-eighth the price.

As regards the generative source, there is now a tendency to use a small dynamo, driven from the engine, which supplies the lighting energy for both interior and exterior lamps.

*Acetylene Lamps.*—This type of illumination is generally confined to the headlamps, although side lamps may be obtained. The gas tail lamp would require too much piping to be a practical proposition, while the self-contained lamp would be too bulky. The various manufacturers have each their own type of generator, whether incased in the body of the lamp, or as a separate accessory mounted generally on the running board. The principle of the generation of the gas consists in allowing water to drip slowly on to calcium carbide. The mechanism should allow of the gas being immediately cut off when required, and the damp carbide should have every opportunity of draining when not in use. Gas lamps have to be kept scrupulously clean, and the gas passages, such as the pipes, taps, valves, and burners, should be kept free so as not to choke. Systematic attention is necessary if a good light is to be depended on at any moment. Spare burners should be carried, and the generator constantly overhauled to see that the gas filtering medium is kept clean. The orifices in a duplex acetylene burner

are extremely small, so that even a small speck of dirt will make a great difference to the shape and size of the flame, not only affecting the illuminating power, but often blackening the reflectors and other interior surfaces of the lamp.

If the separate generator is favoured, a type should be selected which is easy to clean and to examine as to the amount of carbide remaining. An ordinary generator will light a pair of powerful headlights for six hours—no advantage in this respect of electric light. The generator should be as low as possible, while the piping (of not less than $\frac{3}{16}$ in. bore) continually rises to the lamp with an absence of quick curves. The tubing being on the rise, allows the water to run away from the lamp into a special condenser. The metal tubing should be connected to the generator and lamp taps with rubber tubing, so that, as with the water cooling system, vibration is allowed for.

Self-contained lamps burn equally as long as the separate generator type, and a duplex generator is a convenience while one may be kept as a spare. A large self-contained lamp will weigh about 12 lbs., a smaller size 9 lbs., and a separate type about 5 lbs. The generator should be protected by a felt-lined case so that the water is less likely to freeze in cold weather. Self-lighting devices have been placed on the market, whereby the movement of a switch on the dashboard ignites the gas in the lamp. Care has to be taken that explosions do not occur owing to the pressure of gas being too great. Acetylene may be purchased in cylinders ready to use, in which case a generator is rendered unnecessary.

*Petroleum Lamps.*—The oil lamp is an old favourite for all types of vehicles. Side and tail lamps usually burn petroleum, and a good design with well-protected ventilation will burn well even when the car is proceeding at a good pace in a head wind. The body of the lamp, as with all types, should naturally shed the water, and no sharp corners or edges should be presented. The wick should be controlled by an inconspicuous device, and the whole should be strong and of generous proportions in the chimney, while the locking of the door and reservoir should be well designed so that they do not come undone under vibration. Lamps should always be removed when washing the car, and should be fixed clear of wind screens, otherwise they are liable to

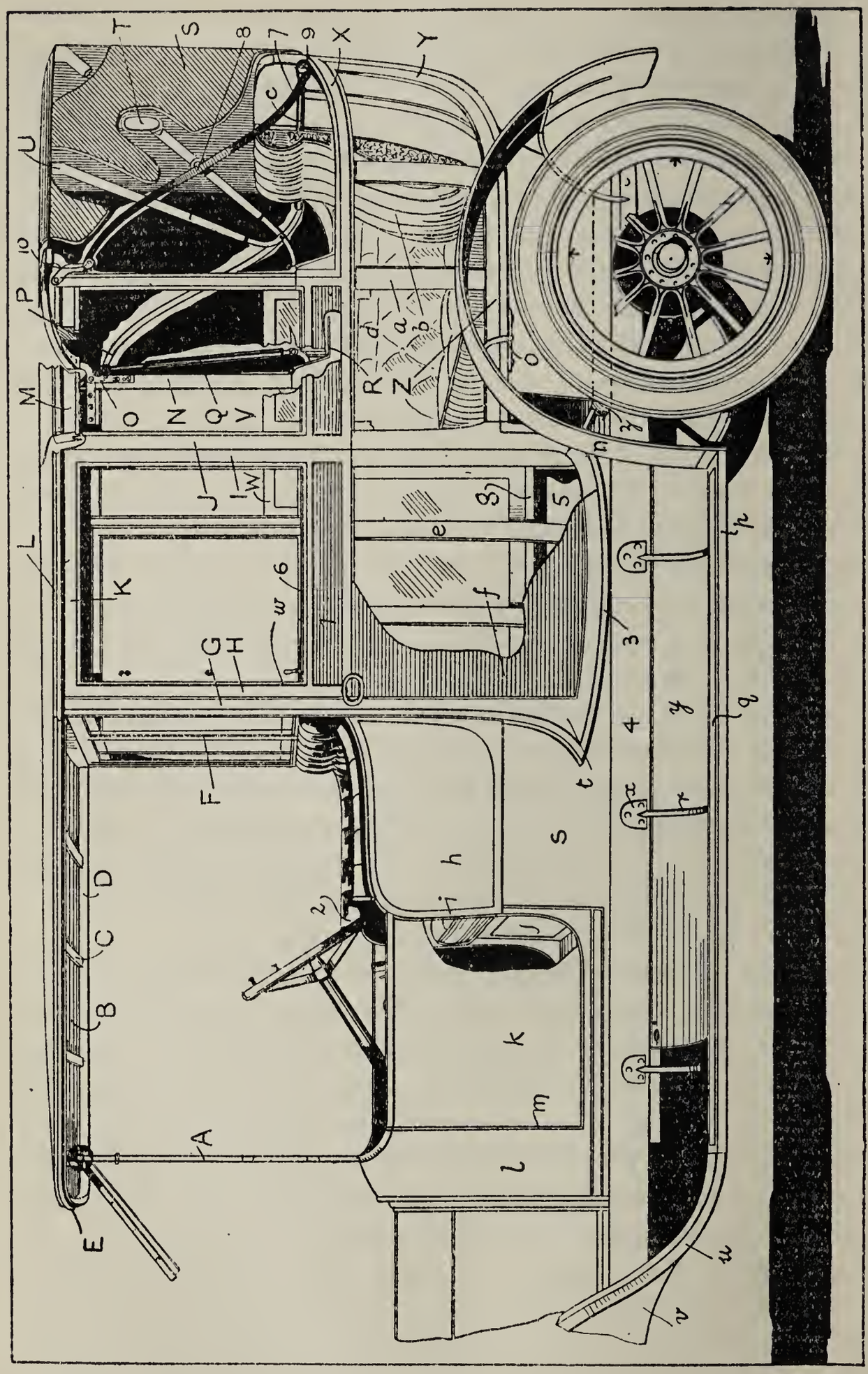


FIG. 18.—Limousine Landaulette, showing the more important parts of a Motor Body.

A Wind screen standard or stanchion.
B Canopy.
C Hoopstick.
D Canopy rail.
E Front canopy rail (with cornice in centre).
F Centre light pillar.
G Front standing pillar.
H Door pillar (shut or lock side).
I Door pillar (hinge side).
J Hind standing pillar.
K Door top.
L Cant rail.
M Cant rail and door top combined, or cant rail.
N Side light pillar top, or pillar top (off side).
O Cant rail hinge, with flap taking hoopstick (off side).
P Outside joint (off side).
Q Head spring (off side).
R Pillar hinge (off side).
S Head leather.
T Back light.
U Head slat.
V Side light.
W Glass frame (off side), top stile.
X Elbow.
Y Corner pillar.
Z Seat or short bottom side.
*a* Panel batten.
*b* Back squab.
*c* Rolling bar of head mechanism.
*d* Side squab.
*e* Panel batten.
*f* Door panel.
*g* Glass frame rest.
*h* Driving seat panel.
*i* Moulding.
*j* Heel board.
*k* Wind or front door.
*l* Scuttle dash.
*m* Door plate.
*n* Hind wing.
*o* Wing stay.
*p* Step edging of long side step, or running board.
*q* Long side step.
*r* Step stay.
*s* Rocker or boot side.
*t* Toe of front standing pillar.
*u* Flange of front wing.
*v* Side guard of front wing.
*w* Wasting.
*x* Step stay flap.
*y* Step guard.
*z* Runner or bottom side.
1 Fence rail.
2 Outside elbow of driving seat.
3 Door bottom side.
4 Web of chassis side member.
5 Door bottom.
6 Fence.
7 Joint end.
8 Knuckle joint.
9 Bottom prop.
10 Top prop.

blow out, also the tail-lamp chimney should not be in direct line with the exhaust outlet. Oil lamps are the cheapest to maintain, but require to be kept clean, although they do not demand the close attention demanded by the gas lamp. A fair-sized side lamp will burn for sixteen hours and weigh four pounds.

Many types of petroleum lamps, both side and tail, are adaptable to electric illumination. A well-known pattern has a back light which unscrews, thereby allowing the electric fitting to take its place, the oil burner remaining in position. Electric-acetylene combinations are also procurable. With head lights, the motorist sometimes experiences delay owing to the centres of his forked lamp brackets not corresponding with those of his new lamps. This difficulty may be overcome by the use of adjustable brackets.

# CHAPTER XV

## *BODY ACCESSORIES*

There is a wide range of accessories, and for the purpose of reviewing the uses of the more important, it will be convenient to divide them into two classes—body accessories, and chassis or motor accessories. The division will, of course, only be an arbitrary one.

*Tool Boxes.*—The inside lockers of the body are seldom of sufficient capacity, especially now that seats are so low, therefore some external box becomes necessary on a car which does any amount of extended touring. The near side step is a favourite place for the box, as the off side is usually occupied by spare tyres, or detachable rims or wheels. Polished wood is a favourite finish, but if the box is painted to match the body, and the surface is prepared with the same care, so far as time taken and the number of coats of paint applied, then the box will wear much more satisfactorily than if french-polished. The sizes of boxes run, on an average, from 11 ins. by 6 ins. by 8 ins. up to 27 ins. by 11 ins. by 11 ins., and generally with some variety of interior partitioning, such as a tray or one or two vertical divisions. The box is fastened to the step by two wood-countersunk bolts. Some prefer a piece of rubber or aluminium matting fitted to the top of the box, so that it may be used as a step, while a piece of plain brown linoleum looks neat and wears well. Tool-boxes, in many cases, suffer from one great defect, dampness. This is difficult to overcome, as the tool-box being bolted to the step, the washer seldom troubles to detach it when cleaning the car, and for that matter, such a course would not be desirable, as an insecurely fastened box might easily mean the box and its contents left on the road. The box, in order to shed the water, should have a lid sloping well to the front, with a metal drip plate running all round just above the line of opening. A

good plan is to have a lid which overlaps the surface of the lower part. Good constructional design will sometimes be noted in accumulator boxes which have a falling front, and the lid and sides of the boxes join up by means of tongue and groove arrangements.

A steel box does away with joints which may leak, while the blocked and rounded edges give little lodgment to moisture. In a box of this description there need only be one seam, which will be at the back, or the four sides may be turned over and rivetted to the base. A very useful tool box is one which displays its contents readily, owing to the fact that the superimposed trays are mounted on lazy tongs, so that a pull to the upper tray immediately brings forward, in a series of steps, the lower trays. The top of a tool box may be used as an emergency seat, in which case the top will be padded with a waterproof material, and a folding back-rest also can easily be arranged.

Tool boxes which carry the necessary spanners, screwdrivers, and other tools, as well as a collection of small spares in a disorderly heap will set up a considerable amount of noise as well as injuring some of the contents. The tools and so on should be carried in the same neat array as in a high-class dressing case, and a place should be provided for every important tool by means of shaped counter-sunks in trays, or suitable leather or other staples. Little articles such as plugs, washers, nuts and bolts will be carried in the smaller partitions, trays, or drawers. Some tool chests have been fitted up on the inside of front doors, where they have the advantage of increased accessibility. A tool box may run the whole length of the step on top, when it is made narrower than the step, and forms a second step to the body, doing away with the necessity for a shield. Boxes of this description are sometimes made of cast aluminium. When the box is under the step, part of the step forms the lid or lids; drawers in this position are liable to get out of order owing to their exposure. A practice often adopted in mounting the ordinary tool-box is to place it half through the step so that it is not so prominent. An important item is the pattern of lock used. This should be of good quality, while the fastening of the lid, which will be an independent fitting, should be of the pull-over variety, so that the lips of the lid are tightly pressed home on the flanges of the sides. One lock and a pair of pull-overs are usually

essential for a watertight job, even in a box 15 ins. long, and the methodical owner will probably have a master key which passes the locks on the tool and other boxes, interior lockers, trunks, and probably a bonnet lock as well.

*Luggage Grids.*—The grid, grille, carrier, or rack for carrying luggage at the rear may be regarded as a standard fitting on bodies not provided with a roof extension. Neatness is obtained when it is made of metal with, say, $\frac{3}{4}$ in. by $\frac{1}{4}$ in. sides, having round corners, and three or four neat cross-bars of $\frac{1}{2}$ in. round iron. The grid, when not in use, should fold in half inwards, and have a stop hinge in the centre, while the strain is lessened at the joint by having a pair of light knuckle joints fastened at the top to the body framework. Grids which collapse like a lattice gate are liable to get out of order, owing to the large number of parts which have to work in unison, while the pattern which slides right in may not always stay where it is wanted. Wooden racks give a sporting appearance to an open car, and, when upward inclined and curved, make a useful game carrier. The back panel may be protected with a few guard rails to prevent chafing, but this will be unnecessary if trunks are carried properly secured to staples on the grid.

*Driving Mirrors.*—In order that the driver may see behind him without turning and taking his attention off the traffic in front, a driving mirror is fitted to the canopy or wind screen stanchion on the steering side. To allow for different heights of drivers and varying positions on different cars, this fitting should have a universal movement and be easily adjusted so that it is under control by the loosening of one fly-nut only. The mirror also has its uses when reversing a car. The glass may be rectangular, when it runs about 8 ins. by $5\frac{1}{2}$ ins., but a lighter and cheaper circular pattern may be obtained, weighing about half as much, which is merely a 6 ins. or 7 ins. circular mirror.

*Trunks.*—These should be specially made for motor work, as the ordinary railway or steamer pattern is not weather-proof enough. Trunks look neatest if they are made to fit the car, especially when they are carried at the rear on the rack, or on the roof. As with a tool-box the locks and fastenings should pull the lid well down, and a secure and rigid attachment is essential, so that the trunk does not chafe itself or the body. The rack trunks are made to the

exact shape of the hind panel, and allowance is also made for the overhang of the seat and the curvature of the panels.

Trunks are usually made of three-ply wood, screwed together, and covered with a thin leather-like material, which can be had in almost any shade to match the car. The top trunk, or any one which has the whole upper surface exposed, should be dome-shaped, so as to naturally throw off all wet. Trunks which one wishes to take into an hotel should be carried in well-fitting cases, either loose covers, or in a chest or cupboard, the latter arrangement increasing the overall dimensions but little.

Roof trunks are made to fit the compass of the roof exactly, and, when stretching right across from one side of the body to the other, make a suitable dress-case for ladies' attire, as such a trunk will be at least 48 ins. wide, sufficient for a skirt. The boxes carried on the grid are more suitable for gentlemen's clothing. When ordering trunks it is a little point of economy to remember that one large trunk is cheaper than two small ones filling the same space, but, of course, when four persons are touring together several cases are a great convenience. Hat boxes are usually designed to go on the step, and 24 ins. by 12 ins. by 24 ins. is the standard size specified by leading makers.

Trunks for other purposes may be carried on the step, such as golf and gun cases—the former being the longer, while the latter are ingeniously fitted up to hold each gun separately, with a compartment for ammunition. Those who dislike the appearance of a spare tyre or wheel carried on the step, can, with a canopied car, carry it in a square or circular box on this part of the roof, the square variety giving more corners for stowing small articles. Either variety is useful in the centre, when divided up, for carrying inner tubes, or it may be utilized as a whole for carrying ladies' and gentlemen's hats. Tyres when carried on the step can be kept clean, and in good condition, by means of close-fitting waterproof wrappers. When a tyre or rim only is carried, then the centre space may be used to insert a special circular case, which answers a similar purpose to the centre of the roof canopy tyre box.

Trunks and hampers are also made to fix under the seats inside, usually the hind one. Dressing-cases, luncheon and tea baskets, and toilet requisites of all descriptions, embracing every detail of

luxury, may be had by those who wish to do extended touring, and be as independent of hotels as possible.

*Communicators.*—Some means of communication between the driver and occupants of the interior of a closed body without having to move from one's seat, is a great convenience. The simplest mechanism is the check string, a piece of silk cord having one end fastened to the chauffeur's coat and the other end passing through the front framing of the body. This is the usual style adopted in horse-drawn carriages.

The communicator, whereby various simple directions may be conveyed, may consist of a mechanical or electrical device. The former has two dials, one fixed inside on the front of the body or conveniently at the side, while the other dial is attached to the dashboard. The inside dial is provided with a handle, which by means of a flexible shaft or Bowden wire transmits a similar position to a finger on the dashboard dial. The electrical communicator has two dials, either of a circular or rectangular shape, fitted inside and out as before. The inside fitting has a number of simple directions, by the side of each being a push-button. When a button is pressed, a corresponding direction is lit up by a tiny lamp under the glass top of the dashboard fitting, and at the same time a bell rings. As there are often seven or eight wires in close proximity, each of which has to work independently, the chances are that the device will get out of order before long, unless unusual care is taken in fitting it up, and each wire is well insulated from the next, also all the various delicate parts are well made and designed, which suggests that only the highest class of electrical communicators should be purchased.

*Speaking Tubes.*—The speaking tube allows of a more detailed direction. The fitting consists of a length of rubber tubing, covered with various materials to match the trimming, with a trumpet at one end, and a mouthpiece, whistle, and bulb at the other. The tube is fastened to the body by special screwed (generally nickelled) rings, which pursue a path according to the type of body. In a limousine the mouthpiece will be placed by the side of the door, near the hind seat on the off side, where it may be easily taken off the holder, and conveyed to the mouth. The tubing will run up the standing pillar, along the cant rail, and out of the body by the

offside corner of the front top rail. The bell mouth of the trumpet should be on a level with the ear of the chauffeur. In a landaulette with folding front, the tubing will be brought up from under the driving seat. The mouthpiece should be protected so that dust, dirt, and air is not driven into the body from the trumpet. The latest patterns have a combined mouthpiece and bulb, while the trumpet is capable of adjustment for different chauffeurs.

*Glass Flaps.*—Instead of a speaking tube, which is considered by some unhygienic, the front light may be pierced, and a hinged or sliding flap of glass inserted. Another plan is to have the front light divided into three vertical portions, the centre or other portion of which is hinged, or made to slide.

# CHAPTER XVI

## *HOW TO CHOOSE A CHASSIS*

THERE are, at least, one hundred prominent makes of cars on the British market, the majority of which are made in several models.

*The Question of Price.*—The first consideration is price. If a man has only two hundred and fifty pounds to spend it will rule out all the higher-powered models, and in some instances, such as the Rolls Royce, Daimler, Delaunay-Belleville, Lanchester, Mercédès, and so on, it will put these makes out of consideration altogether, as a car even at one hundred pounds above the figure stated is not made by these firms.

*Personal Recommendation.*—A definite way of going to work will be something in this way. If the would-be motorist has a friend who has driven with success a make of car which comes within his financial scope, then he cannot do better than get the latest model of that type.

*Visiting the Local Agent.*—If the motorist cannot make up his mind in this way, probably because several friends have cars of widely differing specifications, prices, and behaviour, then he should visit the nearest local agent or agents, and obtain price lists and particulars. This will put him in the possession of, say, half-a-dozen specifications from which he can choose a model within £25 either side of the capital he is prepared to expend. The relationship between horsepower and price need not trouble him, or for that matter, number of cylinders, type of ignition, lubrication, and so on, because the last five years of keen competition has had the effect of levelling up the workmanship and general value of most cars. If he should, in some instances, get a little less horsepower for his money in a certain chassis, the chances are he will get a better piece of machinery than with the higher-powered chassis.

Quality means less delay on the road, and, therefore, in the end, as much mileage as with a speedier car having less perfect mechanism.

*The Body Space.*—When deciding the amount of money he will spend with the motor manufacturer, he should at the same time make up his mind as to the kind of body which will be mounted, so that the two may be properly related. If the make of chassis under consideration is not long enough to take the large landaulette body which is to be adopted, it may be cheerfully rejected for one which has a more generous wheelbase.

*The Question of Delivery.*—All methodical selection may be abruptly defeated by the fact that delivery cannot be made until some months hence. If the motorist is in a hurry, he may be happy in thinking that an equally good car can be obtained without waiting by inquiring in other directions.

*The Man of an Engineering turn of Mind.*—The more a man knows about motor cars, the less easy it is for him to satisfy himself when buying a new car. He will probably worry about accessibility, number of speeds, design of the transmission generally, and a hundred and one other considerations. Probably he has his own pet car in view, then the course is clear, and he follows his bias. Those who hold shares in motor companies, or who know personally any of the staff of a concern, have their path made easy. Generally speaking, the best way is to choose the car which naturally comes within one's local observation, do not tie the expenditure down too exactly, and see that it is long enough for the body required.

*The Car with a Reputation.*—It is always a safe plan to buy a car with a manufacturer's name attached to it. Makes of cars which are well known fetch a good price when second-hand, and in some instances it is possible to judge the merits of a car by the difficulty in obtaining a very cheap second-hand one.

*Steam and Electric Cars.*—The question as to whether the propelling power shall be steam or electricity may assail the motorist. Well, if he cares for steam he has only three or four makes to worry him, and there will be no electric ignition to perplex him, and no gear changing, but at the same time he must not mind being out of the fashion. The electric car, of course, is only intended for short journeys in town.

Apart from price and right length, the would-be purchaser is

always safe in buying a make of car which he has heard of for some years.

*Spare Parts.*—A well-established firm is more likely to keep a satisfactory stock of spare parts, so that a renewal does not entail a big bill owing to parts having to be specially made. Motor shows should be visited merely to add to one's general knowledge of motor engineering and allied industries; they are by their bewildering array not suited for the calm selection of the right car, unless a decision has been arrived at previously.

*Trial Runs.*—Having come to a definite conclusion between, say, two or three cars, a trial run of about one hundred miles should be asked for, with the car loaded to its full capacity. This will give a fair idea of its power of climbing hills, and one can note how the gears change, how much necessity there is for gear changing, how the brakes act (he will ask the car to be stopped without previously warning the driver), and the wise purchaser will arrange for fuel consumption to be noted as against the mileage. If the particular make of car is not purchased, the inquirer should be willing to pay a pre-arranged sum for the out-of-pocket expenses of the trial run. If the trial run is satisfactory, there need be no further anxiety. The next thing is to get the specification, which statement should include all the accessories and tools given with the chassis. The make of tyres should be described, the kind of tread, and size, while the date and place of delivery should be made plain.

*Second-hand Cars.*—Those who have only a small amount to spend will naturally be attracted by the low price at which many second-hand cars are offered. To obtain a bargain, it is necessary to understand how a car wears in use, and also to estimate readily if the amount of wear shown is within reasonable limits to allow further running on an economical basis, or if certain parts are repaired or renewed, whether the cost of these repairs, plus the price paid for the car, constitutes value for money, bearing in mind the cost of a new car. In many instances, if the would-be purchaser has little engineering knowledge, it is a good plan to engage the services of an expert, and the few guineas paid to him will, in most cases, be well expended.

No second-hand car should be bought unless one is given ample leisure to inspect it beforehand. Generally speaking, the car should

be in running order, that is to say, it should not require any great amount of adjustment in order to give a trial run.

The inspection should not be commenced until the car has run a few miles, say a short trip of five miles out and home. During this journey the effectiveness of the brakes can be tested, the readiness with which the front wheels answer to the steering wheel, and likewise the regularity of the firing. Noise and rattle of any kind will also be made apparent. When the car has been run back to the garage, the engine should be left running for a time, when it will be convenient to see if there are any leaks in the water circulation either in the radiator, the piping, hose connections, or cylinder jackets. If any leaks are present in the lubrication system these should be noted by any pools made on the floor or subsequent examination of any under-shield carried. Any defect in the petrol piping will of course materially affect the running of the engine, but it is as well to examine all the joints, and where any attachment is made to the chassis to see that there is no chafing and likelihood of subsequent leakage. After the engine has been stopped, the car should be partly dismantled so that the wear of the engine parts and transmission may be examined, and it may be as well to mention that the motorist should be prepared to pay for this dismantling and re-erection, if not done by his expert, and the car is not bought.

Wear has to be looked for in the main bearings in the crank case, and the pinions in the gear box and differential case. These should be emptied of their lubricant, so that the teeth may be closely examined, while the oil or grease should be examined for metal shavings and dust. Other constantly moving parts are valves, tappets, and cam shafts, and if the steering has seemed defective during the run the amount of play should be ascertained, and whether this may be adjusted, or require a new worm and sector at the base of the column. New bushings may be required in some places, and the services of the expert are particularly desirable in ascertaining the accessibility of the various parts, not only their easy access, but the amount of dismantling required before they can be entirely removed. A good set of tyres may be well worth half the price asked for the complete car. These should be carefully examined for cuts, and the nature of any repairs should

be looked into. It will be as well to have the tyres removed so that the inner tubes may be inspected.

Wear in the body work chiefly shows itself in the tightness of the closed doors and the rigidity of the glass frames when up on the fence. The paint and trimmings will probably be shabby, but torn places and split panels and open joints should be looked for, and their cost of repair considered. In buying a second-hand car one may not be able always to obtain spare parts rapidly, and as a precaution it may be as well to get into communication with the manufacturers, and ascertain how matters stand in this direction.

# CHAPTER XVII

## *THE PETROL ENGINE*

The engine, as used in the majority of motor-cars, has the same principle of working as the ordinary gas-engine suggested by Beau de Rochas in 1862, and put into practical form by Dr. Otto during the next fourteen years, but a different fuel is used, it is much lighter in weight in proportion to the horsepower developed, and the speed of the moving parts is greater, three differences which are necessary, because one is a stationary engine while the other is attached to a road vehicle, in which case reduction of weight and compactness may be regarded as essentials.

The fuel supply is contained in a tank, from whence it passes to a carburettor, which converts the motor spirit, when mixed with a larger proportion of air, into the proper state for being ignited in the cylinder head, which it enters by way of the inlet valve. The mixture is exploded by electrical means, and forces down the piston, so communicating motion to the crank shaft and then through a clutch and gear-box to the bevel drive of the back axle, or in some instances the chain drive from the sprocket shaft.

*The Fuel.*—Petrol, motor spirit, or gasoline such as is generally used for fuel purposes, is distilled from crude petroleum or mineral oil, an inflammable liquid found in certain parts of the world. Petroleum is a complex hydrocarbon, and other useful substances besides petrol are distilled from it, amongst which are other fuels which may be used for motor cars. Petrol, generally speaking, is the most volatile of the products produced, and therefore comes away first from the parent liquid; it has the lowest specific gravity of about 0·68 to 0·71 at 60° F., and gives off vapour at the ordinary temperature of the atmosphere. After being re-distilled and refined so that no residue is present and the right specific gravity obtained, it is ready for use.

Certain precautions are necessary in handling it, as this vapour is highly inflammable when mixed with air, and the vapour being heavier than air there is more danger near the ground than above. The liquid itself is less dangerous, but as vapour is con-

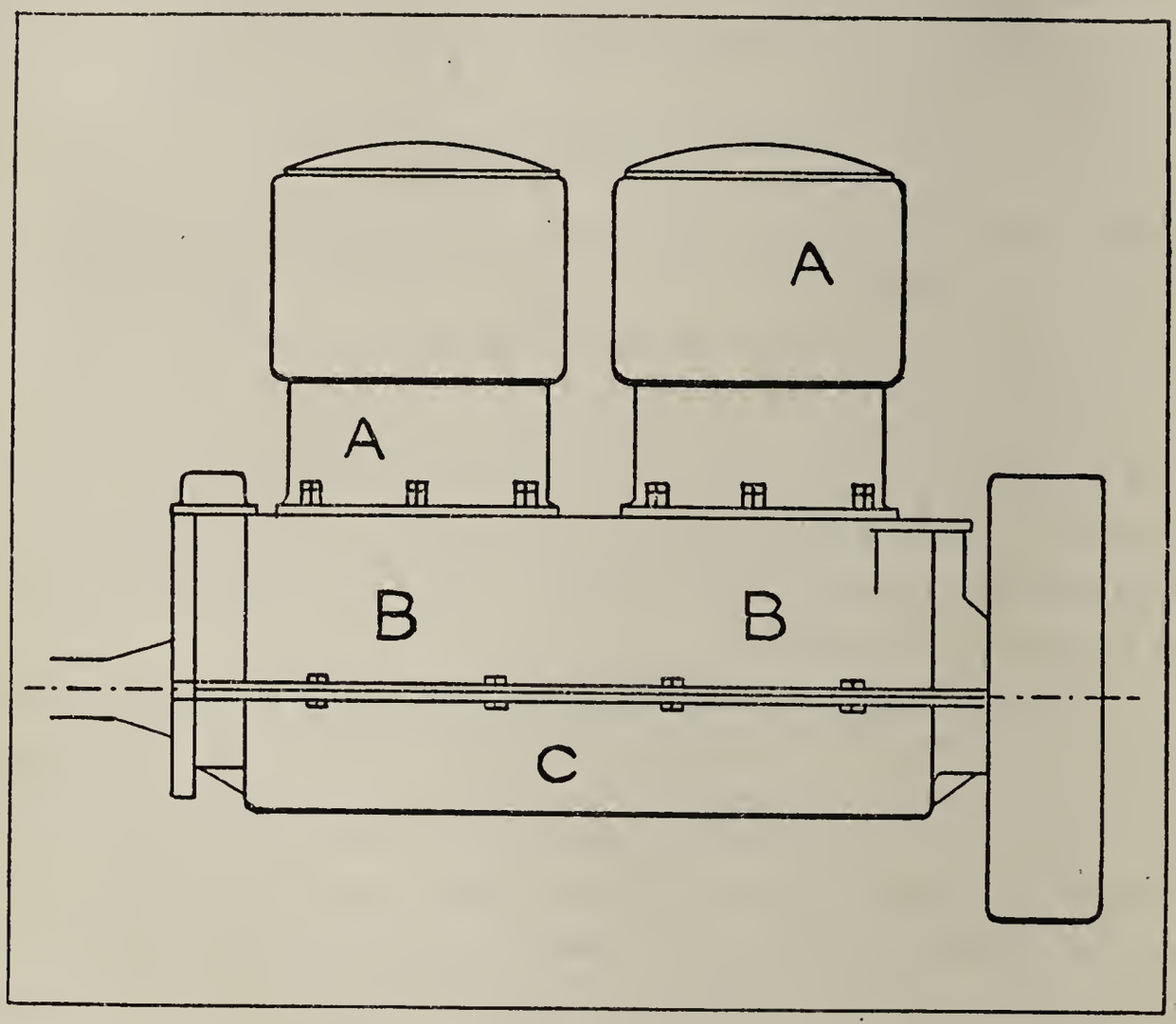


Fig. 19.—General exterior view of petrol engine. A, cylinder casting; B, crank case or top half of crank case; C, lower half of crank case, or oil reservoir.

tinually being given off, naked lights should be rigidly excluded from the immediate neighbourhood.

*Pressure-fed and Gravity Tanks.*—The situation of the tank will decide whether the carburettor is to be fed by pressure or gravity. In the former instance the contents must be pumped up. This is done before the engine is started by a hand-pump fixed to the dashboard, which is in connection with the air-space above the petrol in the tank. This pipe has also connected to it a gauge also fastened to the dashboard, so that the presence of the requisite pressure may be proved (usually about 16 lbs. to the square inch, or 2 lbs. greater

than atmospheric pressure), while a further branch of the same pipe leads by way of a reducing valve to the exhaust pipe. This device has two valves, one of which allows the exhaust gas (usually after passing through a strainer) to enter the body of the valve, while the other is adjusted to allow of a certain amount of outside air to enter and so reduce the pressure. By this means the petrol supply is maintained while the engine is running. An air pump may also be driven by gears from the engine in place of this reducing valve.

The supply pipe, which is quite distinct from the one just mentioned, starts from the bottom of the tank, through a cock, so that the supply may be turned off when required, then through a strainer either direct to the carburettor or through an auxiliary tank if such is carried. It is most essential that all joints and piping should be airtight and well brazed, while the tank filler itself must be screwed home tightly. The reducing valve, hand-pump, and gauge may also be in communication with the lubrication system.

The pressure-fed tank is generally slung at the back of the frame between the side members. Here it is out of the way so far as well-designed body work is concerned, but it is liable to damage from the rear, and if it is too low it is apt to prove a dust raiser.

The gravity-fed tank requires the level of the contents never to be below the jet of the carburettor, and when deciding on its position the maximum gradient the car will be likely to encounter must be taken into consideration. A safe rule is to fit the tank so that there is a 3-in. head of petrol when the car is on an incline of 1 in 5, the measurement being taken from the bottom of the tank to the top of the float chamber of the carburettor.

The tank can be placed under the seat, either side of the dash-board, or behind the back squab of the driving seat, and in the last two instances it is often neatly covered with mahogany panelling. The gravity tank must have a small vent so that air may enter to replace the petrol as it is consumed, which has the tendency of allowing the lighter portions of the spirit to evaporate, especially when the car has been standing for some time.

Tanks differ greatly in shape according to their position, and are made of brass or copper, while cheaper varieties are of lead-coated steel. They must be absolutely sound at all the joints, which should

be well soldered and riveted, and all cocks and connections well designed and fitted.

A high-class tank should have a generous sized filler, and be fitted with a series of two or three strainers having gauze of varying mesh, so that all impurities are entrapped, including water. If the filler is large enough to accommodate the hand it will facilitate cleaning. A refinement in tank design consists of the provision of an extra cock which has to be turned on in order to use the last two gallons of the tank, whereby the driver is warned that his fuel supply is running out. A gauge of some sort is a great convenience.

*Carburation.*—The carburettor is a light aluminium or gunmetal casting whose function is to supply the engine cylinders with the proper mixture of petrol vapour and air, under all conditions of running. There are various problems to contend with, the majority of which can only be combated by means of delicately arranged adjustments. The temperature and degree of dryness of the atmosphere, barometric pressure, road inequalities, the crank-shaft speed, the quality of the fuel, and the residue left from a previous charge, have all to be considered in the design of an efficient carburettor.

A very large quantity of air is used, the proportion of liquid petrol to air being approximately as 9000 :: 1, and that of the petrol vapour and air as 6 :: 1. The chief business then of the carburettor is to induce the air to become impregnated with the petrol vapour, a matter which is more difficult at high speeds than low. In order to impregnate the air drawn into the carburettor by the suction of the piston, it is allowed to travel through as much vapour as possible. In the old-fashioned surface carburettor the air entered the tank itself through a chimney, and was assisted in the saturation process by a baffle plate which tended to imprison the air while it was travelling over the surface of the petrol. Another early means adopted consisted in allowing air to bubble through the petrol, and in another the motor spirit was admitted direct to the seating of an air valve, or the inlet valve itself. An early device, which with modifications has been adhered to up to the present day in one notable instance, is the wick type, in which the air is well mixed with the petrol vapour by passing between the strands of cotton wicks.

*The Float-feed Carburettor.*—The modern carburettor is of the float-feed, jet, or spray type. The petrol pipe from the fuel tank goes directly to what is called a float chamber, which is designed to keep the petrol at a constant level in it and the one communicating —the mixing chamber—where the jet or nozzle is situated. In the mixing chamber the petrol, as it passes out of the jet, is vaporized and mixed with air.

Before entering the inlet valve of the engine the mixture is further diluted through an auxiliary port either attached to the mixing chamber or formed in the inlet pipe. The amount of mixture passing to the engine is adjusted by a throttle valve under control of the driver.

The float chamber works on a similar principle to that of the domestic ball cock. A cylindrical chamber is fitted inside with a hollow metal box or float free to move vertically on a central spindle, one end of which is pointed, forming one part of a needle valve which governs the entrance of the petrol. When the petrol is drawn out of the float chamber into the adjoining mixing chamber, the float immediately sinks, bringing into operation a series of small levers which open the needle valve and so allows the level of petrol to be restored. When the level of the liquid is just below the jet the float causes the levers to work in the opposite direction and close the needle valve. The float is usually made of brass or copper and spun in one piece, the top being soldered on. This reduces the risk of leakage into the float, since should the float become heavier from any cause it will entirely upset the working of the carburettor. Floats, however, are still made of cork on several cars of American manufacture. The float should be dome-shaped or strengthened slightly in some way so that it does not alter in shape, therefore volume, under different atmospheric pressures. The lever mechanism working the needle valve may be above or below, working from a central spindle or independently at the side. The exit from the float chamber into the mixing chamber should be slightly above the bottom of the former, so that any impurities which have escaped the various filters en route shall be intercepted.

As a rule, the air inlet surrounds the jet. The air as it rushes in helps to draw out the petrol, and breaks it up into a number of fine particles. This disintegration may be furthered in various ways.

The spray may impinge directly on to an inverted cone, or other baffle device. The spray being thus diffused, it is more readily converted into vapour, and it is in a suitable condition to impregnate the air. The conversion of the liquid petrol into a gaseous state is attended with a large absorption of heat, which renders the walls of the mixing chamber comparatively cold, and must be counteracted, otherwise it will interfere with the continued evaporation of the fuel. This is achieved by warming the incoming air through the medium of the exhaust pipe, the mouth of the air intake being formed as a sleeve round it, or the warmth of the cooling water may achieve the same object. The control of the rate of entry of the air, estimated roughly at 10,000 ft. per minute, is a difficult problem to surmount, chiefly because the internal combustion engine of to-day has such a wide range of speed. A throttled-down engine may be revolving only at 100 revolutions per minute, while with the throttle wide open on a good level road it may be moving at twenty times that rate. As the suction increases, the mixture is liable to get too rich in petrol, because the air has a tendency to drag, and such a mixture does not readily ignite.

*Some Modern Types.*—The recognition of this property of air in motion has brought into being carburettors having multiple jets controlled in various ways, so that air is drawn across a fewer number of jets the lower the speed of the engine. In the Polyrhoë carburettor there is a continuous line of tiny jets along one side of a rectangular throat. In this throat, which is arranged horizontally, moves a piston which is withdrawn by the engine suction. The greater the speed, and therefore suction, the further the piston is drawn out of the throat, and the greater the number of jets exposed to the rush of air. The "T. & M." multiple-jet carburettor is also a horizontal piston type, and has three jets arranged under the throttle piston. The main air supply to the tube into which the jets open is cone-shaped, and the end exposed to the atmosphere is covered by an adjustable shutter, in the centre of which is placed an auxiliary air valve having a coiled spring attached, and so arranged that as the engine suction increases, more air is admitted to the choke or jet tube. There is also an extra air inlet, the opening of which coincides with the throttle opening. With the White and Poppe carburettor the spray hole can be varied in size, instead of

increasing the number of jets used. It is drilled slightly out of the centre of the nipple. Free to turn upon this nipple fits a thimble having a similar eccentric spray hole, which in one position will coincide or register with the first-mentioned one. The cover containing the second hole is connected to the throttle and rotates with it. When the throttle is fully open these two holes are in line, while any movement of the throttle restricts the jet area, and so keeps the mixture constant for all openings of the throttle. Over this throttle is fitted a movable sleeve controlling the quality of the mixture.

Carburettors are made in many varieties, and will continue to be so as long as each motor manufacturer constructs his own according to his particular theory on carburation. There has been of late, however, a tendency for makers to adopt such types as are made by specialists.

The float chamber need not be at the side of the jet chamber, but in some instances is concentric with it; likewise ball valves are used in place of needle valves controlled by the float, and as already pointed out, the vaporizing passage may be either vertical or horizontal. The air supply is subject to many modifications; generally there are two passages, one of which is controlled by a valve, while the valves used may be the ordinary poppet type, the piston type, or of a simple flap or butterfly pattern. Having obtained the correct mixture, it then has to be delivered to the various inlet ports by means of suitably designed piping. The inlet pipes should be arranged so that the mixture has to travel the same distance in each case, while as little interference as possible is made with the new charge by the one immediately before it. The mixing chamber of the carburettor is therefore placed centrally by the side of the engine casting, and close to it, so that the piping is short, ensuring a minimum of alteration in the mixture, and also to assist in the compact designing of the type of piping or manifold used.

It is essential that the mixture provided by the carburettor should be suitable for the work to be done, as not only does loss of power and waste of fuel result, but trouble is caused by overheating and sooting in the combustion chamber. The jet and other parts should be accessible so that cleaning may be easily carried out, for it

is of vital importance that the spray hole should be scrupulously free from grit, or foreign matter of any kind.

*The Engine.*—The petrol engine is situated in the front part of the frame in modern cars, a position which has been chosen chiefly for its accessibility, but it adds to the length of the chassis, tends to distribute the weight unevenly, and influences the length of the transmission system. It is, therefore, not ideal from the mechanical point of view, but the bonnet, under which the engine is placed, being a prominent external feature, was soon looked upon as a characteristic element of a car, so that even those who were striving to evolve a perfect road engine were driven to adopt the popular style, or fail commercially, and there are very few firms who have had the courage to place the engine so that the wheel base is not unduly influenced thereby.

The typical engine operates vertically, and may have one to four, six, or eight cylinders, the four-cylinder type being the most favoured for cars of medium power. The cylinder casting may be carried out in various ways, so as to include one to four cylinders in a group. The casting will again vary as to the disposition of the valves, and the arrangement of the water jacketing, the whole being influenced by the crank shaft, and its bearings in the crank case below.

The cylinder casting is bolted to the upper half of the crank case, which not only provides the top bearing for the crank shaft, but in most cases the lower bearings are attached directly to this part of the crank case also, so that the lower portion may be removed separately, and inspection carried out with a minimum of trouble.

The cylinder casting provides the slide bearing for the valve stems, while the tappets which operate them have their bearings usually supported on the crank case. The crank case is designed to accommodate the timing and other gears which work the valve cam shaft, water and oil pumps, and magneto. The cam shaft runs inside the crank case, the internal webs of which provide suitable bearings.

To the top half of the crank case is attached the lower half, often called an oil base, as it is chiefly used as an oil reservoir, and seldom to support the crank shaft underneath, so that it may be

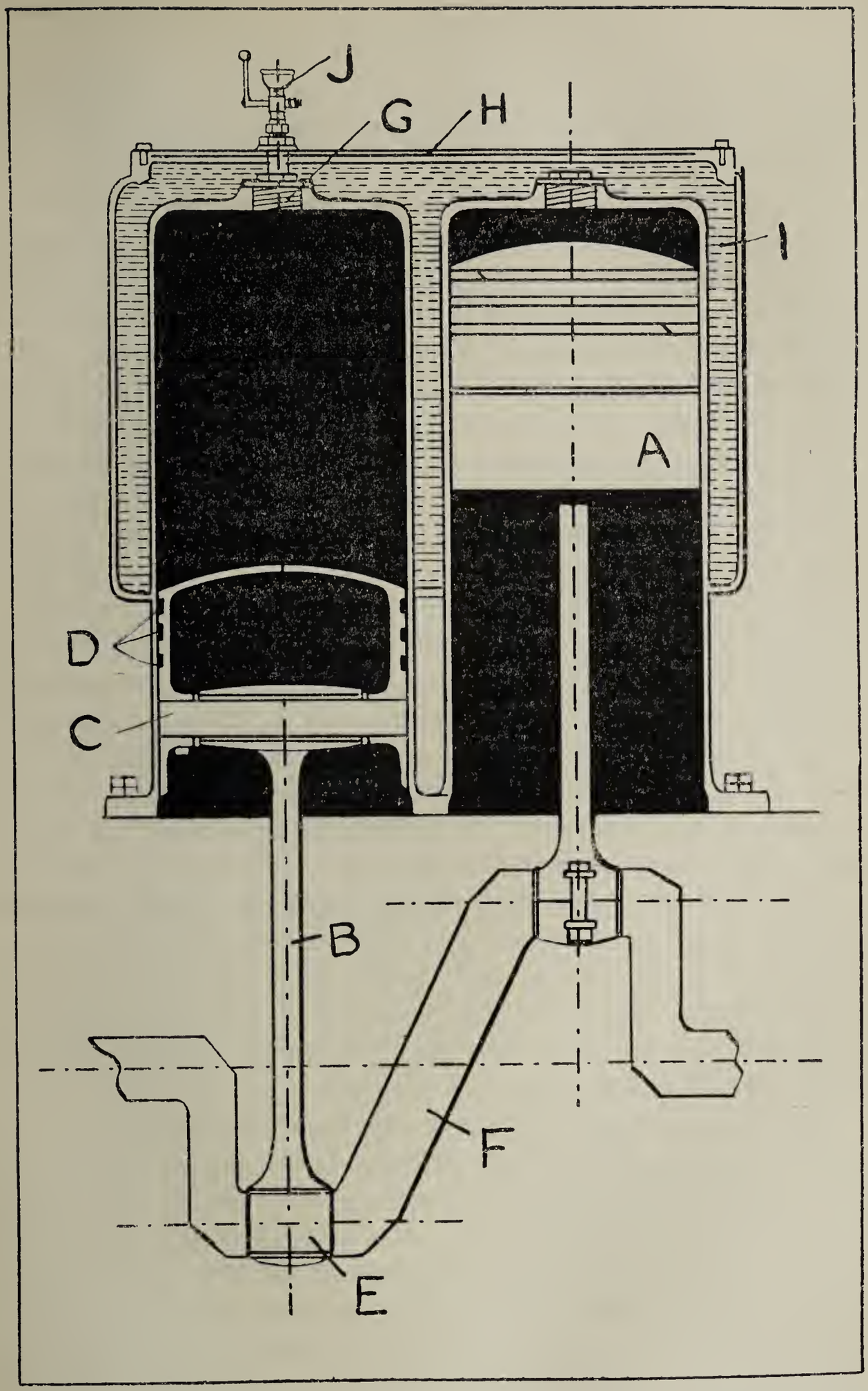


FIG. 20.—Section through a pair of cylinders, showing the arrangement of the pistons, connecting rods and crank shaft. A, piston; B, connecting rod; C, gudgeon pin; D, piston rings; E, big end of connecting rod; F, crank web (angled); G, cylinder plug; H, jacket top or cover; I, water jacket; J, compression tap.

constructed lightly in aluminium. The upper half of the crank case has arms so that it may be fixed either direct to the main or a sub-frame.

*The Otto Cycle.*—The principle under which the engine works—the Otto cycle—consists of four distinct motions, which take place during two complete revolutions of the crank shaft. The piston being at the top of its travel, it moves downwards in the cylinder, and the inlet valve being opened, usually by reason of inter-connected mechanism, a vacuum is created in the inlet pipe leading to the carburettor. This draws a charge of the mixture into the cylinder, and the piston having arrived at its lowest point, the inlet valve closes. This is the inlet or inspiration stroke. Next the piston rises again in the cylinder, no valves being open, so that having arrived at the top the charge of gas which has just filled the cylinder is now compressed within the confines of the combustion head, the area lying between the top of the piston and the dome of the cylinder casting. The gas being compressed it is exploded by the electric spark at the right moment by being inter-connected like the valves with the movement of the engine. This compression stroke is immediately followed by the downward working stroke, the result of the explosion. No valves are open until the piston reaches the bottom of the cylinder on the working stroke, then the exhaust valve opens, resulting in the burnt gases being expelled through that opening while the piston is performing the upward exhaust stroke. This being completed, the exhaust valve shuts, and the inlet valve opens and the piston once more performs the inlet stroke, and so on through the cycle of four operations, which continues as long as the engine is running.

*Valve Timing.*—The valves do not open immediately at the beginning and end of the piston strokes. It is usual for the exhaust valve to open before the piston reaches quite the end of the working stroke, so that the pressure within the cylinder shall be as near as possible equal to that of the atmosphere, and the next upward movement—the exhaust stroke—shall be carried out with a minimum expenditure of energy. The exhaust valve also does not close exactly at the end of the exhaust stroke, but is kept open during a small portion of the inlet stroke, this having the effect of clearing out thoroughly the remains of the explosion. Regarding the inlet

valve, this opens somewhat late, so that the incoming gas enters a well-swept cylinder, and likewise it does not close until the compression stroke is creating a pressure equivalent to that of the incoming charge. The gas, as it enters the inlet valve, has a certain momentum, so that it will continue to enter for a short time, even when the piston is ascending. This timing of the valves differs slightly with various makes of engines, and even with different models made by the same firm. The exact point of opening and closing is expressed by the number of degrees from the vertical the cranks are at the critical moment.

*Engine Arrangement.*—The engine, and its parts, and the various accessories which are assembled closely to it vary in their arrangement considerably, and their method of disposal is one of no little interest.

The position of the carburettor has already been touched upon. Its height will depend on whether the petrol feed is by gravity or pressure, and will be in the centre, so that the length of inlet pipe is equal to each inlet valve. It will not be confined necessarily to a particular side of the engine, but usually it will be found on the inlet valve side.

*Valve Position.*—In designing the cylinder casting one leading question is the position of the valves. These may be on either side, all on the same side, all on top, either vertically, horizontally, or at an angle, or the valves may be on the top and at the side as well. When the valves are either side, that is, inlet one side and exhaust the other, a T-shape cylinder head is formed, and was the leading style until recently. Such an arrangement is symmetrical, and provides easy access to the valves, and the valves are not limited in size, but there is a slight disadvantage in that the combustion chamber is given a larger surface than would be obtained by other means. The larger the surface of the combustion chamber, the more chance there is of the heat being conveyed away at the vital moment of the ignition, thereby destroying some of the force of the explosion or working stroke. With the valves on either side there is a necessity for two cam shafts to work them, but if they are all on one side, one shaft and its pinion wheel, and other details, except the cams themselves, are avoided. This arrangement of valves creates the ⅂-type cylinder casting, a similar shape being adopted

when the inlet valves only are on the top. This ⅂-shape cylinder gives a more ideal combustion chamber, but if compactness is studied the size of the valves is limited if none are on the top. Some successful cars are fitted with all the valves in the head. The advantages claimed for this design are that they are easily got at, the sides of the cylinder are left free for other articles, the inlet and outlet of the gases are along direct paths, and the cylinder is easy to clean; but on the other hand the transmission arrangements are somewhat more complicated, especially if the valves are set at an angle, in order to get the heads of good area. If the inlet valves are on the top and the exhaust valves at the side, then the former allows of easy inspection, and facilitates entry of the gas, while the latter are in a position to be efficiently water-jacketed where it is most needed.

The Maudslay engine has all the valves and the cam shaft as well mounted overhead. The crankshaft below is provided at the forward end with a skew-gear wheel, which drives another at right angles fastened to a vertical shaft. At the top end of this shaft is a universal coupling and another pair of skew gears, so that the motion can be transferred from vertical back again to horizontal, while the coupling is provided with a hinge, so that the cam shaft may be hinged back bodily when required. The Germain engine has an overhead cam shaft driven by chains, while the Pipe engine is a type where the cam shaft is in the normal position, and the movement of the cams is transmitted to the valves by long vertical rods and rocking levers.

*The Cylinder Casting.*—The cylinder casting is made of hard, dense pig iron, the quality selected being one which will flow freely when being cast, will machine easily and smoothly, and provide a good wearing surface. The analysis of the iron should betray a comparative absence of sulphur. The length of the cylinder casting depends on the number of cylinders and whether they are cast singly or in batches. Four cylinders are often cast in twos or all together (*en bloc* or monobloc), or a six-cylinder engine may be arranged in three "twos," or two "threes." So far the six-cylinder engine has not been cast as a whole in any quantity, and no uneven arrangements have been found advantageous. The cylinders are cast together to make the engine more compact, but by having one

cylinder as close as possible to the next, it will be readily appreciated that a limit will be placed on the size of the valves, so that a monobloc casting is particularly suited to one set of valves only being at the side. Some castings do not provide for water jacking between pairs of cylinders. This gives extra compactness, and though it would appear to be wrong to allow part of the cylinder to go uncooled, yet most successful engines are designed in this way. The monobloc style gives a neat appearance to the engine, and it is quite possible to cast on the exhaust jacket and its cooling ribs with it. In designing this important casting care has to be taken to guard against unequal expansion, while ample valve and water-jacket areas must be provided.

*The Number of Cylinders and Order of Firing.*—The cylinder walls are from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick. Two cylinders may be used for engines of 20 horsepower and under, but above that four or six cylinders should be adopted. Approximately one 6-ins. cylinder, two $4\frac{1}{2}$-ins. and four 3-ins. cylinders develop at the same piston speed equal power, but the less the number of cylinders the slower the desirable car speed, and the heavier the flywheel necessary. The flywheel is sometimes half the weight of the engine, and in a single-cylinder engine it has to carry the crank shaft round during $1\frac{1}{2}$ revolutions out of every two, as there is only one working stroke in four. The impulse at the crank shaft of a multicylinder engine is also controlled by the order in which the piston descends, and it is usually arranged that there is never more than one cylinder between the piston which is descending on its working stroke, and the one which has just performed that operation. Therefore in four-cylinder engine the firing is in the order of 1, 3, 4, 2, or 1, 2, 4, 3.

*Pistons.*—The pistons are usually a hollow iron casting, but they may be made of cast steel or malleable cast-iron, or formed by welding together two halves of pressed steel. The steel pistons are a little lighter, but they are more expensive and liable to seize. Lightness is striven for because it means smoother working. Between the piston and the cylinder walls it is essential that there should be a gastight joint, although one must slide in the other. This is carried out by furnishing the walls of the piston with grooves, and springing therein three and sometimes four cast-iron piston rings, which are split for the purpose. In order that the

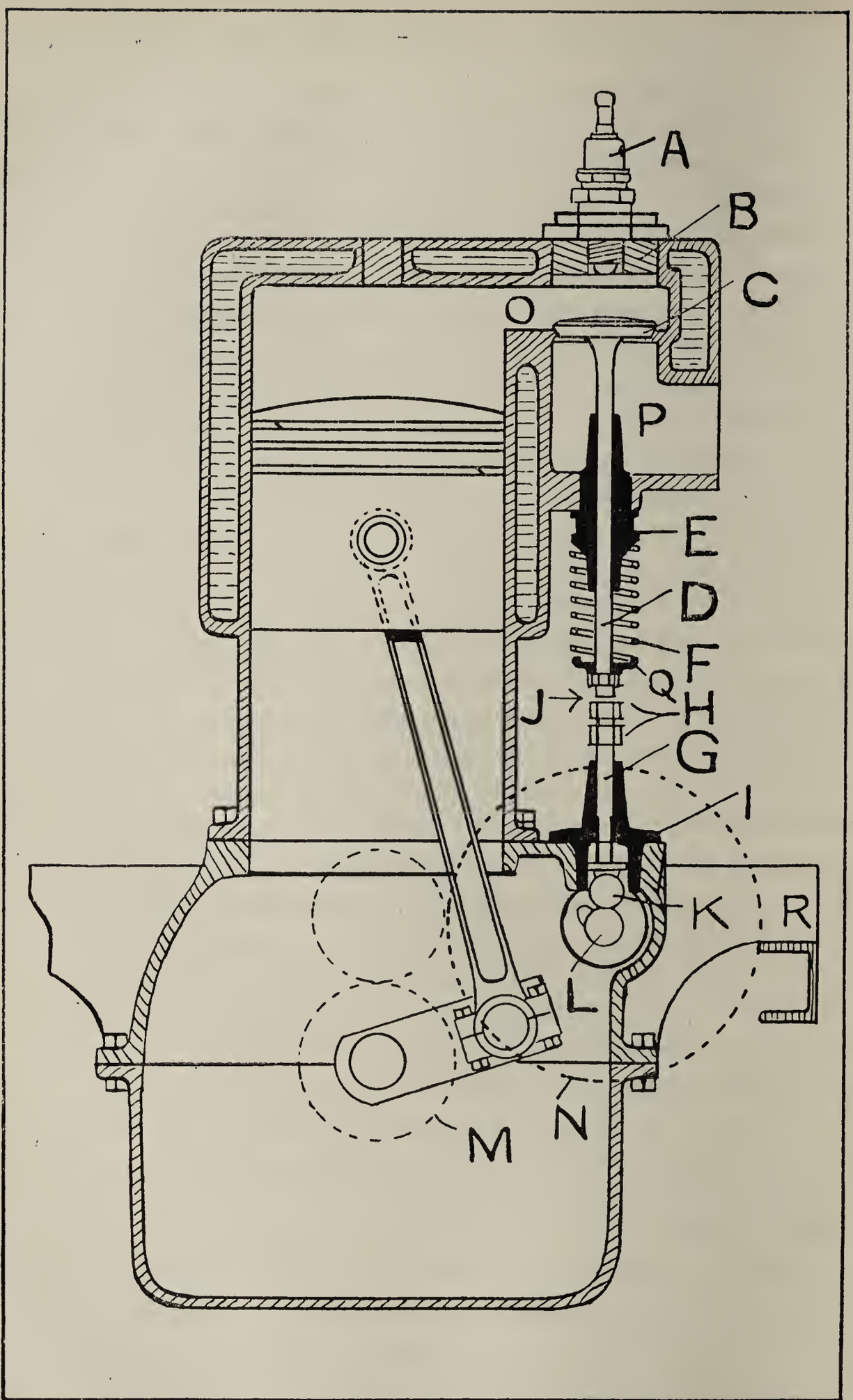


FIG. 21.—End section of a petrol engine. A, sparking plug; B, valve cap; C, valve head (coned); D, valve stem; E, valve guide; F, valve spring; G, tappet; H, adjustment of tappet; I, tappet guide; J, clearance between tappet and valve stem; K, roller of tappet; L, cam shaft; M, pinion on crank shaft; N, pinion on cam shaft; O, cylinder port; P, valve chamber; Q, cap, supported by cotter, holding base of spring; R, crank case arm bearing on chassis.

rings shall spring together tightly at the cut they are made from a tube which has the bore machined out eccentrically, therefore the rings when they are cut off from the tube are wider at one side, gradually tapering to the other where the cut is made. A simple diagonal cut is best, as it is less liable to fracture, but the stepped joint has been ingeniously designed so that one ring encircles the piston twice. The piston, if slightly domed, is more able to withstand the pressure of the explosion, and is attached to the connecting rod at the small end by means of the gudgeon pin inside, which is attached to a bearing each side of the piston walls. The gudgeon pin is made a fixture to the piston in various ways and is case-hardened to resist the wear of the small end of the connecting rod. The gudgeon pin centre should be at the centre of the piston bearing surface. The piston is very slightly tapered towards the top so that where the heat is greatest it may have a chance to expand. Lubrication channels are formed in the cylinder walls, and the water jackets extend just to the depth of the stroke.

In viewing the cylinder and crank shaft from the end it is usual to have the centre of the one immediately over that of the other, but the experiment has been tried of off-setting the cylinder (*desaxe*) so that the two are not quite in line. For this arrangement it is claimed that the angle of the connecting rod is lessened, therefore the side thrust in the downward working stroke, although it may be increased a little on the upward compression stroke, the balance of the two being a saving in wear and tear on the parts involved.

The connecting rod will most likely be a steel stamping of I, round, or rectangular section. As the connecting rod is always under compression, no matter what part of the cycle is being performed, the I-section rod is the best to resist bending, while the round shape may be drilled for a lubrication channel so as to convey oil to the gudgeon pin. The bottom or big end of the connecting rod is attached to the crank pin between two of the throws or cranks of the crank shaft, and it is necessary to make the big end in two halves so that it may be fitted, except in a single-cylinder engine, where it can be pushed over the end.

*Water Jacketing.*—The design of the water jacketing also influences the cylinder casting, after the valve position has been decided. In some cases the water jackets are separate castings, or

they may be of sheet metal. The water jacketing should provide equal cooling facilities all round, and be of ample bore and simple section so that no awkward corners are provided to impede the free movement of the water or harbour steam.

Each valve is provided with a valve cap in the cylinder casting

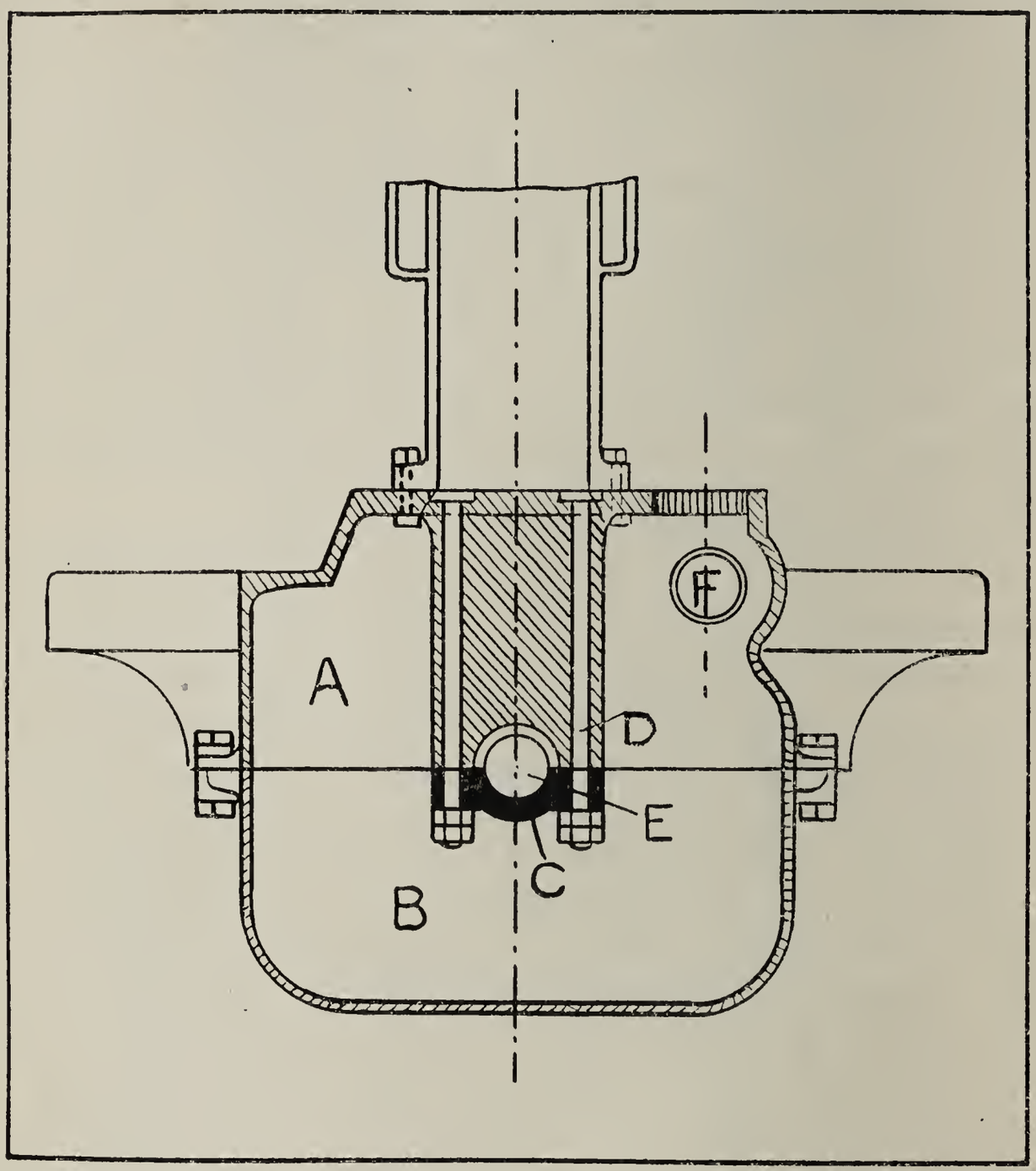


FIG. 22.—Method of supporting crank shaft in top half of crank case. A, B, top and bottom halves of crank case; C, bottom bearing on crank shaft; D, suspension bolt; E, crank shaft; F, cam shaft opening in web of crank case.

large enough to pass the valve head through when it is required to remove it, and there will be plugs screwed in at the top of the cylinder, which make a gas and water-tight fitting with the hole

which was made necessary in order to support the core in casting. The valve cap is often bored to take the sparking plug, and the cylinder plug the priming cup and compression tap. There will also be various lids and covers provided for facilitating inspection of the cylinders and valves.

*Crank-shaft Bearings and Crank Cases.*—The cylinder casting design, besides depending on the valve and cooling arrangements, is largely influenced by the position of the crank shaft bearings. Space is saved by having one bearing to more than two cranks of the shaft, but where expense and good design is of less importance than compactness, there is a bearing to each pair of cranks. It will be understood that a minimum of bearings is striven for when the cylinders are cast *en bloc*, but the whole width of two bearings is not saved in, say, a four-cylinder engine, since it is necessary to have a somewhat longer bearing to each one if there are three than if there had been five bearings. The crankshaft is strengthened at the flywheel, sometimes bored for lubrication, and may be built up, made as a stamping, bent to shape, or machined from the solid, and the forward end is adapted to the attachment of the starting handle. The lower half of the crank case, as pointed out, does not usually provide a bearing for the crank shaft, but this is situated in the heavier top half. It is utilized as a cover for the crank shaft and as an oil bath, is usually so constructed that a small trough is immediately below each big end, into which a small scoop can operate at each revolution, and a bulkhead or baffle plate is provided so that the oil is kept in its proper place when the car is on a gradient.

*Valve Mechanism.*—Returning to the consideration of the valves, there is yet to discuss their design and actuating mechanism.

The valve, which is of mild or nickel steel, consists of a more or less flat head, usually called a mushroom head, attached to a thin stem, under which, vertically in line, is a valve tappet or push-rod, another thin rod, whose lower end is in contact with the cam on the cam shaft.

The valve head is somewhat stronger if it is slightly domed, and the edge is countersunk so that it may fit into a similar seating in the valve port. This shape has been found to make a more gas-tight joint, and is easier to regrind when necessary (for which reason

the head is slotted to receive a screwdriver or similar tool) than a valve which is flat underneath. Strength to withstand the force of the explosions and the continual hammering is also gained by swelling out the neck of the stem immediately under the head, and also enlarging the diameter of the stem some distance down, so that it may better resist the heat of the exhaust gases. The old-fashioned engine was fitted with automatic inlet valves, which were operated simply by reason of the difference in pressure between the outside air and that in the cylinder during the inspiration stroke, and consequently were unreliable for punctual working at high speeds, so they were abandoned. These valves also had to be made large, light in weight, and with a small lift; but now that all the valves work mechanically, it has been possible to make the inlet valve as small as the exhaust valve, and with a longer lift. Consequently it has become a common practice to make the valves interchangeable, and the design to depend on the requirements of the exhaust valve, which are somewhat more exacting, owing to the greater temperature present.

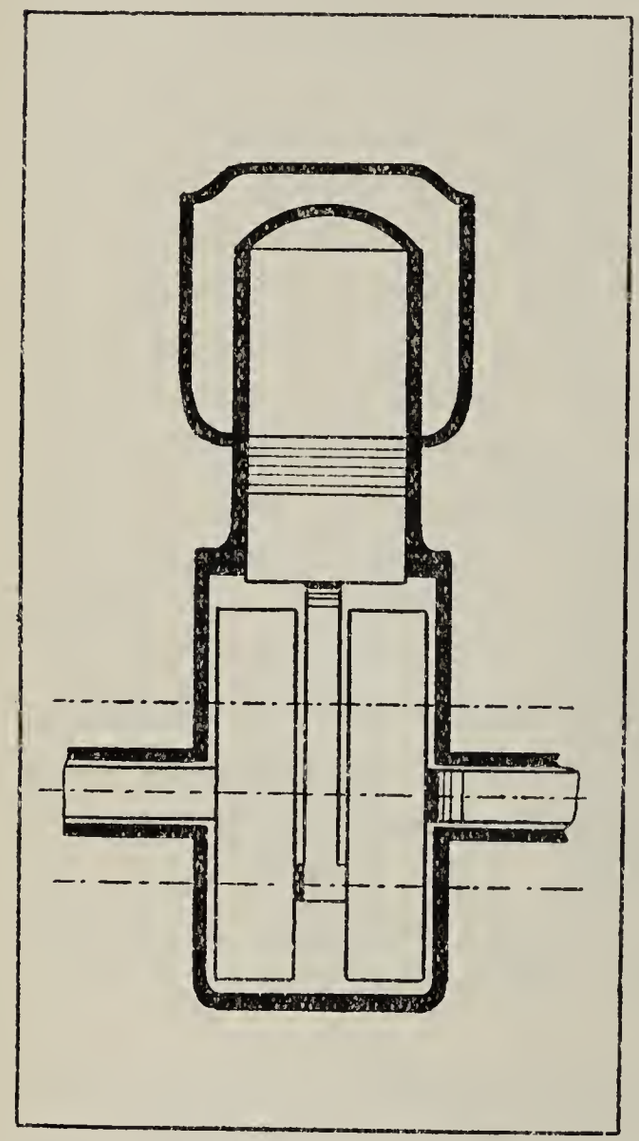

FIG. 23.—Single-cylinder arrangement with split flywheel.

The upper end of the valve is supported in a guide formed in the valve-chamber of the cylinder casting. Immediately below a coiled spring encircles the stem, having its top bearing under the valve chamber, and its lower one on a cap or collar kept in position by a cotter pin passing through the stem. This spring is compressed as the valve is opened upwards, and brings it smartly down again when the tappet rod below falls. This tappet rod is also supported in a guide, often of

bronze, fastened to the crank-case, and usually strengthened at the base. It is necessary that the tappet rod should be accurately fitted in the guide, so that no wobbling action takes place and so create undue wear and tear. At the bottom of the tappet rod a roller is centred, which comes directly in contact with the cam. The tappet rod is often made to respond to the working of a coiled spring in

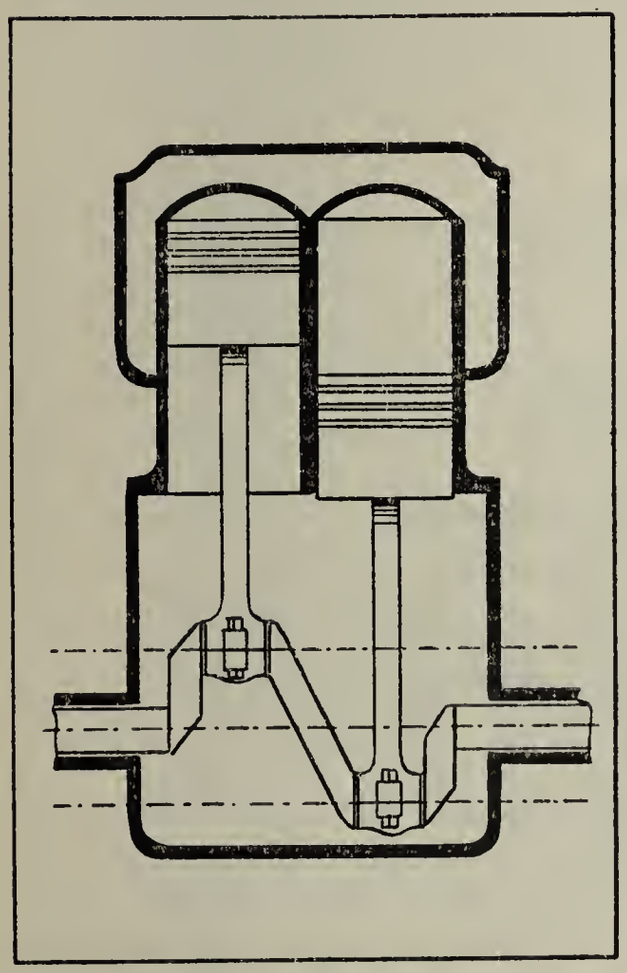

FIG. 24.—Two-cylinder crank shaft arrangement, cranks set at 180 degrees. No water jacketing between cylinders.

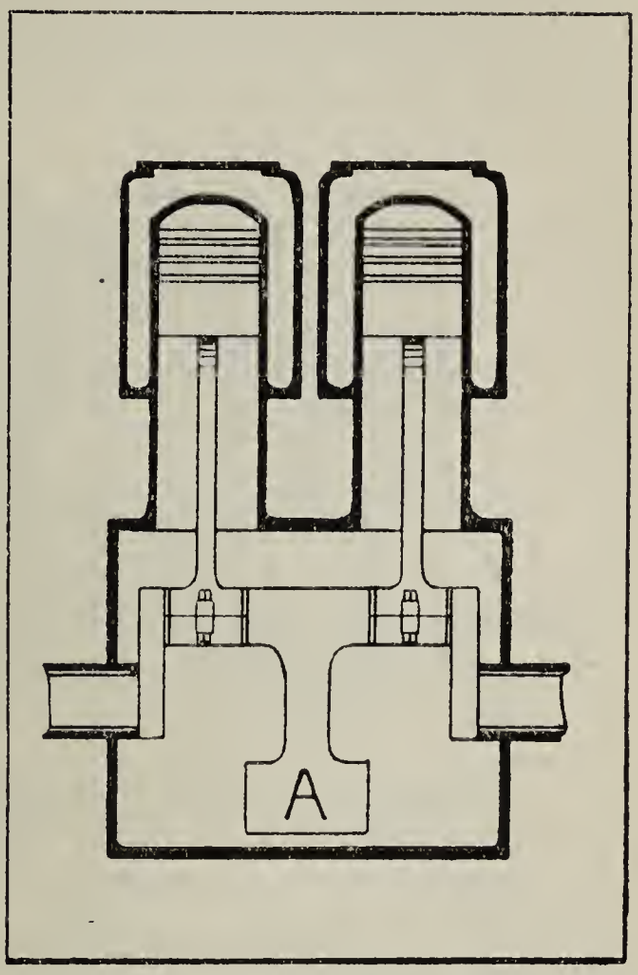


FIG. 25.—Two-cylinder crank shaft arrangement, cranks set together. A, balance weight. Separate water jacketing to each cylinder.

a similar manner to the plan adopted for the valve itself, the spring being inserted in the guide.

The valve stem does not rest directly on the end of the tappet rod, but a small clearance (about the thickness of a visiting card) is left, so that it may be assured that the valve drops right on to its seat when it closes. In order that there shall not be too much clearance between stem and tappet after the engine has been run some time, a good car will be provided with a tappet adjustment, so that by adjusting a pair of nuts the tappet will be pulled upwards

the required amount. A non-metallic pad at the top of the tappet is considered by some to ensure quieter running, which is nowadays further enhanced by enclosing the whole valve system of stems and tappets with a side plate, while the grouping of the valves all on one side, creating fewer working parts, necessarily means less noise. The striking ends of the valve stem and tappet rod will probably be case-hardened and bevelled, so as not to burr over. It is necessary that the valve and its mechanism should be light, so that it may

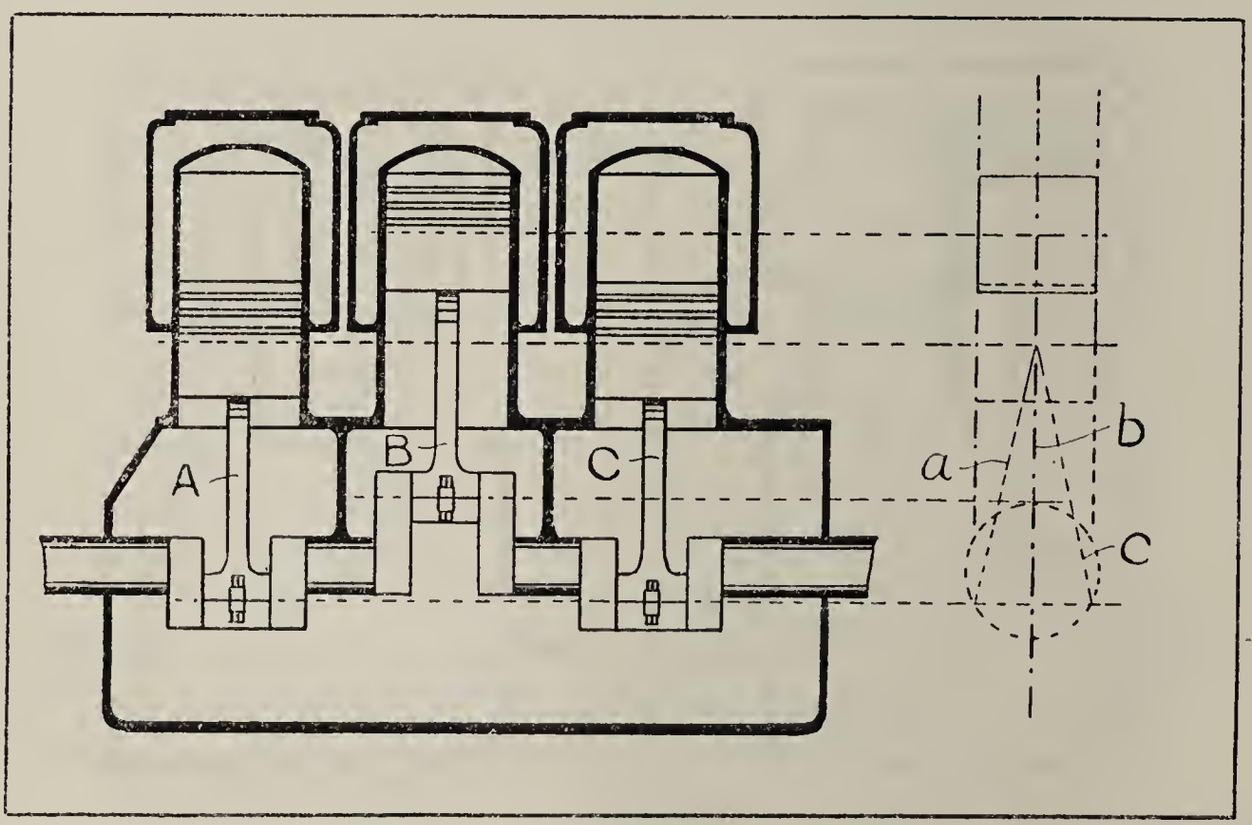


FIG. 26.—Three-cylinder four-bearing crank shaft arrangement. The end diagram shows the setting out of the connecting rods, A corresponding to *a*, and so on. Separate water jacketing to each cylinder.

open and close readily, at, say, ten times a second, a distance of one-third of an inch.

*The Cam and other Shafts.*—The cams which operate the tappet rods are attached to a cam shaft by pinning, or, as is frequently done, they are formed out of the solid. The design of the cam is of great importance, and on its profile depends the smart working of the valve. The cam shaft has bearings in the crank case casting which may correspond with the number of crank shaft bearings. The shaft can be passed through a hole large enough to pass the cams, or it may be placed in lengthways, a long cover-plate being afterwards bolted on. The shaft revolves at half the speed of the

crank shaft, because each valve is only required to open once during two revolutions of the crank, therefore a pinion wheel is attached to the end of the cam shaft, which has double the number of teeth to a similar one keyed to the crank shaft.

These timing wheels are encased, the crank case being designed to embrace them.

If the pump and magneto are driven at right angles to the cam shaft, then some form of bevel or skew gearing is provided.

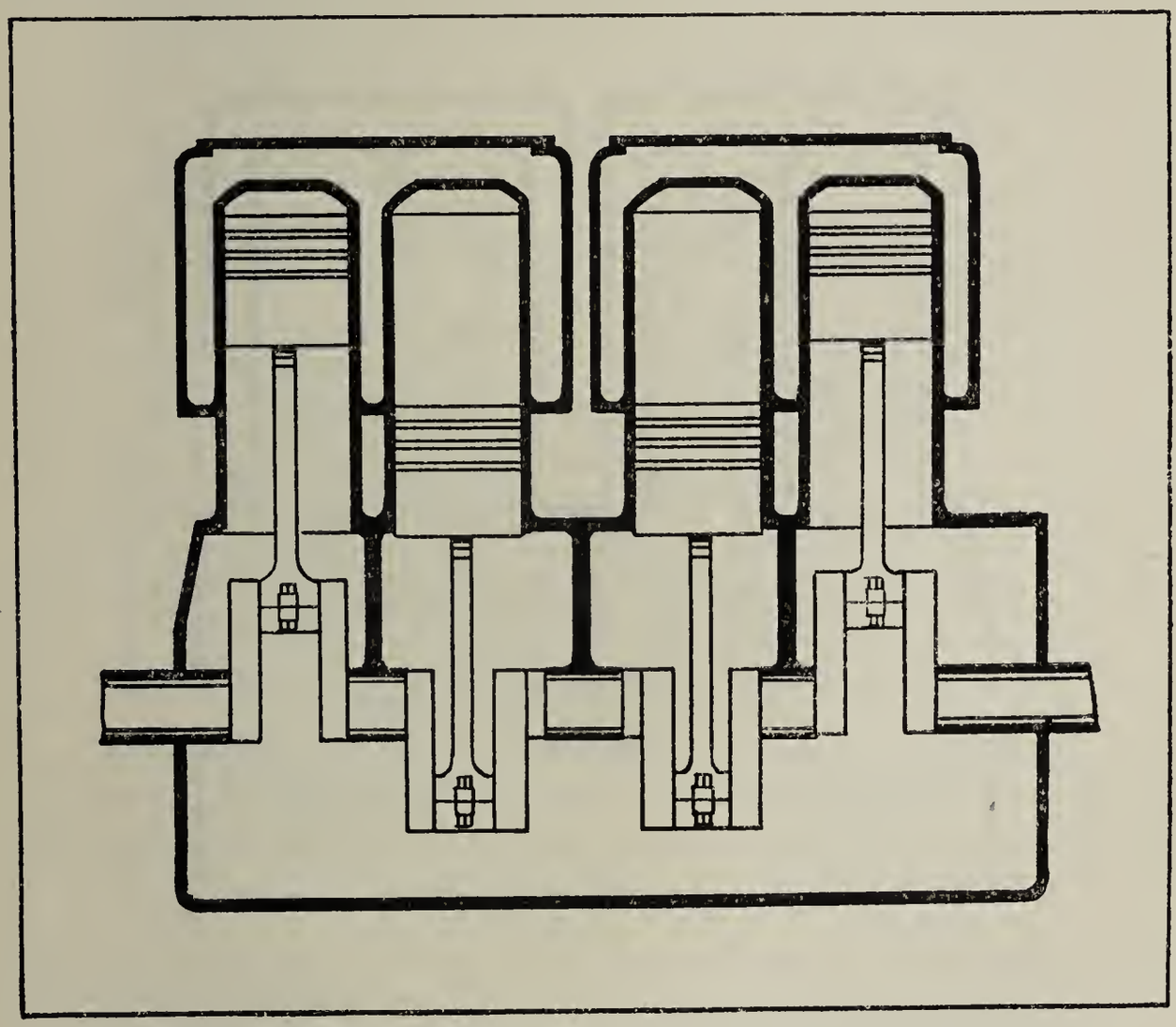

Fig. 27.—Four-cylinder, five bearing, crankshaft arrangement.

In many cars the carburettor and magneto are carried on the same side, the latter being either at the front or rear of the engine. The rear position, being a drier one, is considered the best, as there is no dampness to produce short-circuiting, and also the wiring is shorter if there is any part of the ignition apparatus, such as a coil, on the dashboard. If the magneto is provided with a good cover, there is little danger of a spark finding its way to the

carburettor, but this danger may be considered by some to be sufficient to warrant placing the magneto and carburettor on opposite sides of the engine. If the magneto, pump, and fan are driven from the same shaft, it is a convenience if any of them can be dismounted without disturbing the others, a consideration which applies in designing other parts of the car.

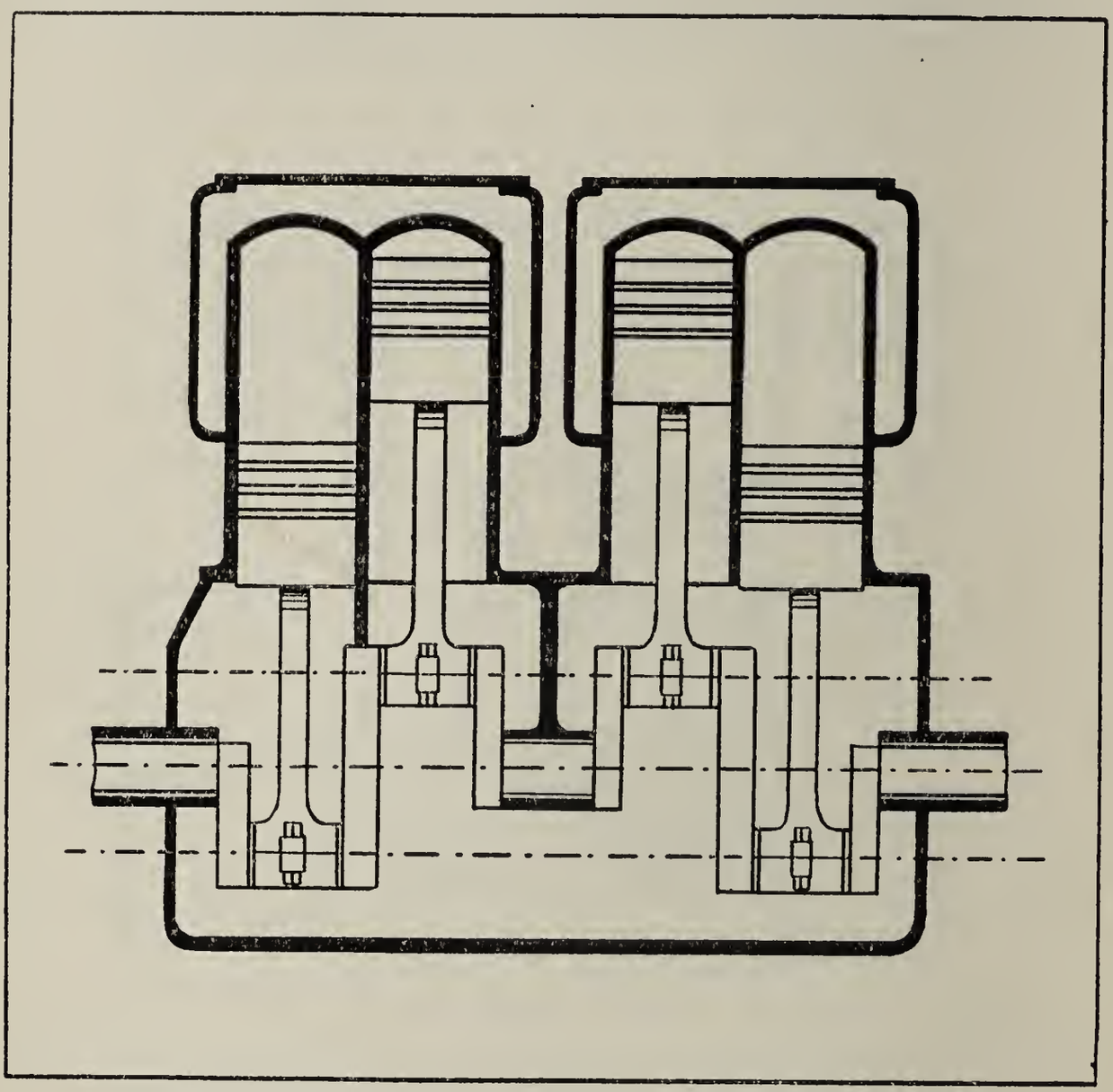

Fig. 28.—Four-cylinder, three-bearing, crank shaft arrangement.

The design of the cylinder casting will vary also according to the method of assembly used. It is becoming customary to continue the casting right back to the clutch, where a machined facing receives the gear-box. The casting will not necessarily embrace the flywheel, as this may be carried right in front, a position which increases the car road clearance. Arms are provided for bolting

the engine to the frame, and if three-point suspension is adopted (which is considered to allow for whip of the frame without jamming), the engine then will have a single bearing at one end.

*Sleeve and Piston Valves.*—The sleeve-valve engine, as applied to the Daimler, Rover, Minerva, and Panhard cars, is an interesting deviation from the normal design. Here a water-jacketted cylinder is surrounded by two concentric sliding sleeves fitted so as to slide independently inside and outside one another respectively. Each sleeve is provided with horizontal slits or ports. When the

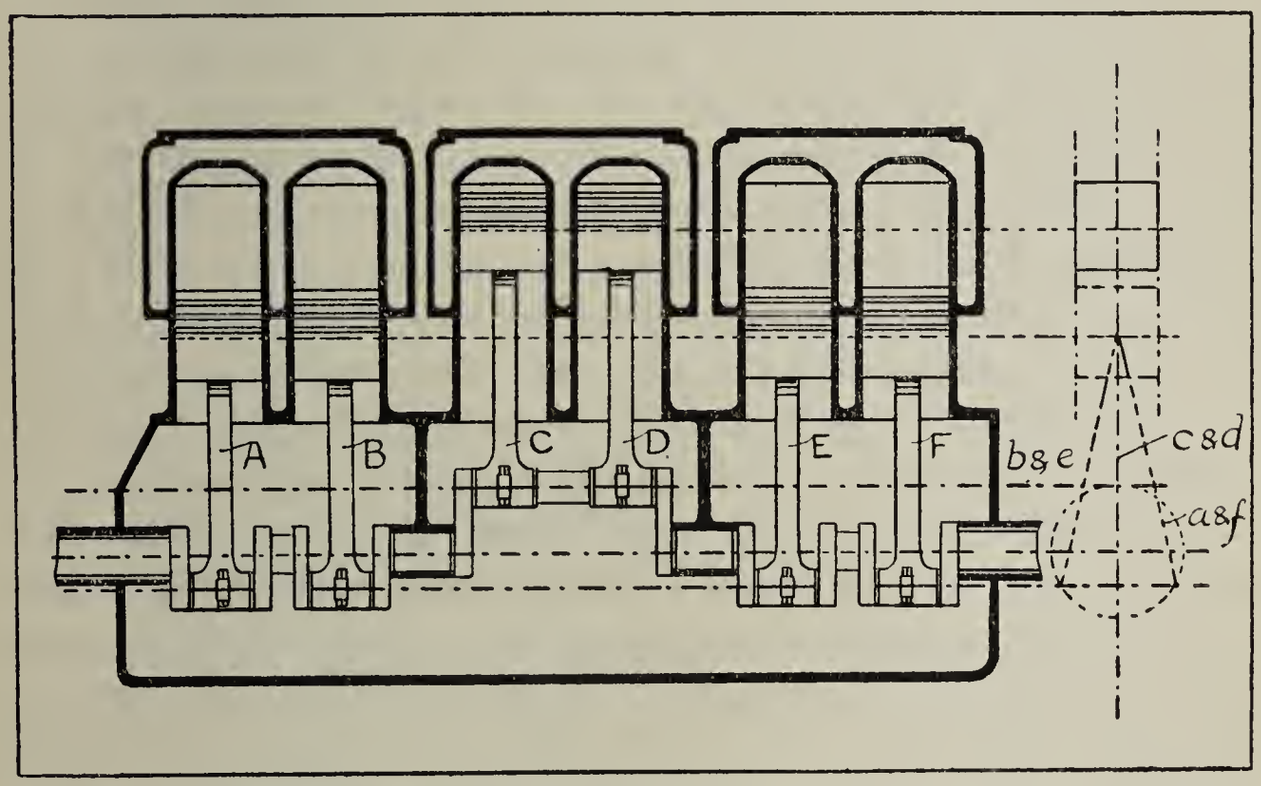


FIG. 29.—Six-cylinder, four-bearing, crank shaft arrangement. The end diagram shows the position out of the connecting rods, A corresponding to *a*, and so on.

ports of both sleeves register together on the inlet side, the gas is drawn into the cylinder by the downward stroke of the piston in the usual way, and likewise a similar pair come into line during the expulsion of the gases on the other side. These sleeves are worked by being connected at their lower ends to connecting rods which have a throw from a small crank shaft situated in a similar position to the ordinary cam shaft, and in this case driven by a chain from a small pinion on the main crank shaft. Each sleeve has its separate connecting rod, the outer one being the longer, although the throw is the same. The ports are so arranged that when two on the same side register, the two on the other side are well apart, so

that there is no exit on that side, and *vice versâ*. These sliding shells extend right up into a cone-shaped combustion head, which is detachable, and it is provided with a set of three narrow and one broad piston rings, so that gas may not escape upwards, while the usual piston rings in the piston prevent the escape of the gas downwards.

Other types of sliding valves are the true piston ones, which operate in a small cylinder of their own, and may be actuated from a small crank shaft either at the usual side position or on the top.

*The Exhaust Pipe and Silencer.*—When the burnt gases leave the exhaust port, they are carried along the exhaust pipe by reason of the pressure present into the silencer situated at some convenient spot near the rear of the frame. The gas in its passage often warms the air inlet of the carburettor, creates pressure for the fuel and lubrication feeds, and sometimes a foot warmer in the body. The pressure remaining is dissipated by the special construction of the internal arrangement of the silencer. The cooling of the gas by the ribs on the first portion of the exhaust pipe initially reduces the pressure. The silencer is divided into several compartments by perforated baffle plates, so that as it passes from one chamber to the other, the gas is cooled, and broken up into many streams. The exhaust pipe is ample in area, so that pressure is not increased, while a direct path assists towards the same object. The control of the exhaust gas must not be too drastic, otherwise a considerable amount of back pressure will result, and power thereby be lost. If the ignition is faulty, an unexploded charge may get into the silencer, which will probably be ignited by the next charge. A silencer has to be dismantled every 3000 miles or so for cleaning. If well designed it will allow of a smooth issuing of the exhaust at a low pressure, therefore with little noise on impact with the atmosphere. The noise which results if no silencer is fitted is made use of with the exhaust cut out, as mentioned later on.

*The Two-Stroke Cycle.*—It is also possible to work an internal-combustion engine by a different set of valve operations other than the Otto cycle. With the two-stroke engine, the crank chamber has another office to fulfil, for the inlet valve opens directly into it instead of at the upper end of the cylinder. The cylinder, piston, and crank chamber are similar to that of the four-stroke engine,

but besides the inlet valve opening into the crank chamber, there is an independent passage-way from this part of the engine leading to the cylinder, and opening at the level of the top of the piston when it is at the bottom of its stroke. Opposite, in the cylinder wall, is the exhaust port. The inlet valve opens at the upstroke of the piston, drawing in a charge of gas into the crank case. This is an initial operation, and not part of the working cycle. The next time the piston moves downwards in the cylinder, the gas in the crank case is compressed, the valve in the crank case allowing of entry only. The gas being compressed, therefore endeavours to escape, consequently passing through the independent passage into the cylinder above the piston. The piston then returning upwards compresses this charge, and the pressure being reduced in the crank chamber more gas is drawn in, so that in this upward movement of the piston, compression is taking place above the piston, and suction below it. The charge above is then fired in the usual way, and when the piston has descended, the exhaust gases are allowed to escape by way of the exhaust port, while during this movement the gas below has again been compressed, and the exhaust being still open the compressed gas removes the residue of the exhaust gases. This simplicity has been taken advantage of for marine work, and there are signs that the two-stroke engine will be more largely adopted for road work, especially as improvements are continually being made. This type of engine needs an easier working carburettor.

A variation of the two-stroke type is employed in the Valveless car. This engine has two vertical water-jacketed cylinders, with a combustion chamber and an air-tight crank case common to both. The connecting rods are attached to two flywheels, having teeth so that by intermeshing the pistons move together, but the flywheels in opposite directions, so reducing engine vibration to a minimum. There are no engine valves, but only an inlet and exhaust port. The first charge having been drawn in by hand, the ascending pistons compress the gas above them, and work the air inlet of the carburettor below, which is so placed that the air only is drawn into the double crank chamber, although it causes the jet to work, but the mixture can only pass above the pistons. The charge being fired, the pistons descend past the exhaust port, most of the burnt gases

escaping, while simultaneously the inlet valve is opening, allowing the fresh gas to enter, which is forced upwards by the compressed air passing from the crank case, which, as before, drives out the residue of exhaust gases. The pistons then re-ascend, closing both ports, and the cycle of operations is repeated.

*Horsepower.*—However ingeniously the engine may be constructed, and its various accessories arranged, this will not compensate the motorist if his car does not develop on the road the power anticipated. Power, it should be remembered, is not simply force, when considering its technical meaning in mechanics, but is the *rate* of doing work. Therefore, in order to arrive at the useful output of an engine, we must have data relating to force, time, and distance. The unit of power is one horse power, and although it was based by James Watt on the work of a powerful horse, it may be as well to dissociate the term entirely from the work of that animal, and remember it simply as 33,000 ft.-lbs. per minute, or the force required to lift 33,000 lbs. one foot in one minute; so that, to determine the horsepower, we have to calculate in foot-lbs. the work done in one minute and divide it by 33,000.

The speed at which the engine works is expressed at so many revolutions per minute, while the distance is calculated by the piston-travel or stroke; therefore the piston speed will be the engine revolutions per minute multiplied by the stroke. The force developed will depend on the compression present at the moment of firing less the force absorbed by producing the compression, and various frictional losses in the engine and transmission system.

From the elementary point of view, the greater the piston speed, the greater would be the expected engine power, but after a certain point has been reached, the real effective power does not increase with the engine speed because the friction is not proportionally overcome, and vibration will also be increasing, which in a high-class motor-carriage has necessarily to be done away with as much as possible.

The less distance the piston has to travel the sooner it will be able to communicate a complete revolution to the crank-shaft, but leverage is lost, the throw of the shaft being half the piston-stroke, and it is difficult, therefore, to maintain a high speed.

A short stroke allows of a lighter engine, but to develop the same

horsepower a short-stroke engine would be moving faster than one with a longer stroke; therefore there would be more wear, tear, and vibration for the same amount of work done. Length of stroke has a decided effect on weight, therefore in motor cars this is not exceeded beyond what is absolutely necessary, and in the majority of cases bore and stroke are within a little the same; generally the stroke is slightly in excess of the bore.

The stroke, however, may be increased in the future if the present taxation horsepower formula is unaltered.

The bore of the cylinder multiplied by the stroke expresses the volume swept by the piston, but does not include the remaining portion between the head of the piston when at its highest point, and the top of the cylinder head. This space is the volume occupied by the mixture when it is compressed, and the ratio between these two volumes decides in some measure the force developed.

The expanding force occurring on ignition depends also on the strength of the spark, and, however well the cylinder and piston may be designed, it can be easily made ineffective by a weak or faulty ignition. Again, the quality of the mixture itself must be up to the mark, but a strong spark will often compensate for a weak compression or even a faulty charge, so it can be seen how important it is that the electrical equipment of the car shall be the best procurable and maintained at its highest efficiency.

# CHAPTER XVIII

## *IGNITION*

In the internal-combustion engine the mixture of petrol vapour and air is drawn down into the cylinder from the carburettor in an uncompressed state, quite incapable of doing useful work without further treatment. The next and upward stroke of the piston compresses the gaseous mixture, thereby imparting to it a certain amount of heat with an accompanying desire to expand, but not sufficient for the purpose required. The charge, however, is now confined within the narrow limits of the head of the cylinder, and, if it is further heated, or, better still, set alight and exploded, it will desire to expand with a considerable amount of force, and according to the amount of heat generated, and the area of the chamber which contains the gas at the moment of ignition, the greater will be the pressure exerted on the piston to send it downwards on its only really working stroke.

As the petrol engine cranks revolve generally at more than a thousand revolutions a minute, and there is one explosion stroke in every four, an efficient explosion will be required some five hundred times a minute, as each stroke represents half a cycle of the crank; that is to say, the explosions take place more than eight times a second, even for a one-cylinder engine. This rapid firing can be effected by the repeated entrance and withdrawal of an igniting agency, or the presence of a continual source of heat. In some types of ordinary factory gas engines the flame is automatically admitted to the cylinder-head at the proper intervals through a slide-valve, or a portion of the cylinder-head has a platinum tube fixed into it, which is kept at a red heat by a bunsen burner playing upon it. This method was used in the earliest type of motor cars, and was known as tube or lamp ignition.

The speediest, cleanest, and also safest method of doing many

things is by electric agency, and stationary gas engines were designed with electric ignition some time before the days of motor-cars, and, as all modern petrol engines have electric ignition, it is evident that for once an older system, having been improved, has prevailed; in fact, one may look upon tube ignition as a temporary system adopted while the one with more defects yet greater promise was brought into line with new and ever-increasing requirements.

*Sources of Electricity.*—To obtain a spark for the explosion in the cylinder-head we may use (1) a primary battery, (2) a secondary battery or accumulator, or (3) a contrivance which is capable of converting magnetism (produced mechanically) into electricity, which is usually a magneto-electric machine (commonly called a magneto) having permanent field magnets, and seldom, so far as ignition purposes are concerned, a dynamo, which has electro or temporary magnets.

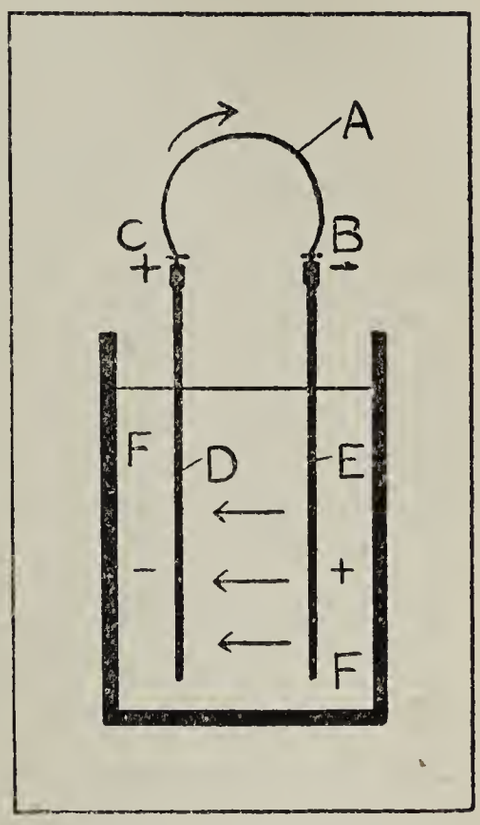


FIG. 30.—A simple cell. A, conductor; B, negative pole; C, positive pole; D, negative plate; E, positive plate; F, electrolyte. The arrows indicate the direction of the flow of the current.

*Primary Batteries.*—A primary battery sets up a flow of electricity within itself by reason of the chemical change which takes place. A battery is a number of cells. The simplest cell is merely a clean piece of zinc, and one of copper or other dissimilar metal, called the eloctrodes, plates or elements, immersed in a pot of weak, generally sulphuric, acid, which is called the electrolyte, and joined together by a piece of conductive material at their dry ends or poles. Whenever the two poles are bridged over, or in other words the circuit closed by a conductor, usually a copper wire, the flow of electricity is set up, and it is manifested by bubbles being formed on the surface of the copper element. These bubbles consist of hydrogen gas formed from the corrosive action of the acid on the zinc element. A primary cell, in order to work economically, must have these gas bubbles destroyed as far as possible, therefore the element on which they would be formed is surrounded by a substance which usually

converts the hydrogen into water. The Leclanché cell has a zinc element and a carbon element, the latter being placed in a porous pot in order to keep the contents together, packed round with crushed carbon, and manganese dioxide, and then, together with the zinc element, placed in a glass jar containing a strong solution of sal-ammoniac (ammonium chloride). Such an arrangement is a wet battery, and only suitable for stationary work, but by introducing plaster of Paris, blotting paper, or other absorbent material, the electrolyte is stiffened up so as to form a "dry" battery, chloride of zinc being added to keep the paste moist. As gas is generated, a vent must be provided to allow of its escape.

The zinc element is the positive one, and is gradually eaten away. It does not take the form of a plate or rod as in a wet cell, but forms the case of the dry cell itself. Here it may be conveniently assumed the current of electricity starts, from whence it travels through the electrolyte to the negative element, and through it to the positive terminal or junction with the conductive wire.

*Accumulators.*—Primary batteries, by reason of the chemical action set up, become useless in time. The accumulator differs from the primary type in that the chemical change produced can be removed, and the original condition of the plates restored, also the elements are active in themselves in a primary battery, and require no current to cause them to develop electrical energy as in the case with accumulators. In the place of a zinc case containing a carbon element, we have in one type of accumulator a series of lead plates cast in the form of grids or gratings, so that they will retain a paste.

If two lead plates are immersed in a dilute solution of sulphuric acid, and connected up to a primary battery or other generative source, the lead plate by which the current enters will be turned brown, and is called the anode. The brown colour is owing to the oxygen gas forming on the surface of the lead plate, and combining with it, resulting in lead peroxide. Hydrogen gas is liberated at the other plate, or cathode, but no chemical action takes place. The plates are now "formed," and ready to liberate electrical energy. A quicker process, however, is to prepare the lead plates by casting them in such a form (generally a grid) that they may easily receive and retain a paste. The anode or positive plate is given a coating

of red lead paste, treated with dilute sulphuric acid, so that lead sulphate is formed, while the cathode or negative plate receives a paste of litharge, also treated with dilute sulphuric acid, so that lead sulphate is again formed. On connecting up with an electric current, as mentioned with the plain lead plate above, the positive plate is reduced to brown lead peroxide, while metallic lead results at the negative plate, which is, of course, slate grey in colour.

A pasted plate is known as the Faure type, and one that is not so treated is called a Planté plate. Most accumulators are of the Faure pattern, some have a Planté type anode, and a Faure type cathode. The efficiency of an accumulator depends largely on the degree of accessibility the acid has to the surface of the plates. Therefore the more porous they are the better, and the various types of castings used are designed, apart from paste-retaining properties, with the object of giving as much surface to the electrolyte as possible.

When an accumulator has given out its energy, both the negative and positive plates return to their lead sulphate condition while the acid solution becomes weaker. On re-charging the cells the sulphating disappears, and the acid solution returns to its former density.

The negative and positive grids are arranged alternately in each cell of an accumulator. Each cell is insulated from its neighbour, that is, it is separated by material which will not conduct electricity.

*Amperes, Volts, and Watts.* — The positive grids are all connected together, likewise the negative ones. Whenever electricity is set up in a cell, it is present in a certain quantity, or can flow at a certain rate, and this is called the amperage.

The pressure at which a current of electricity is delivered is called the voltage. The units of these are expressed in amperes and volts respectively, while their product, that is the power furnished by a current of certain amperage flowing at a certain voltage, is so many watts.

*Series and Parallel Coupling.*—If we have two cells in a battery and join the two positive poles together and similarly treat the negative ones, we shall be coupling up the cells in parallel, while if the negative terminal of one is connected to the positive of the next this will be coupling up in series. The first operation will

increase the amperage, that is electric energy will be given out for a longer period but at a lessened pressure, while the second method

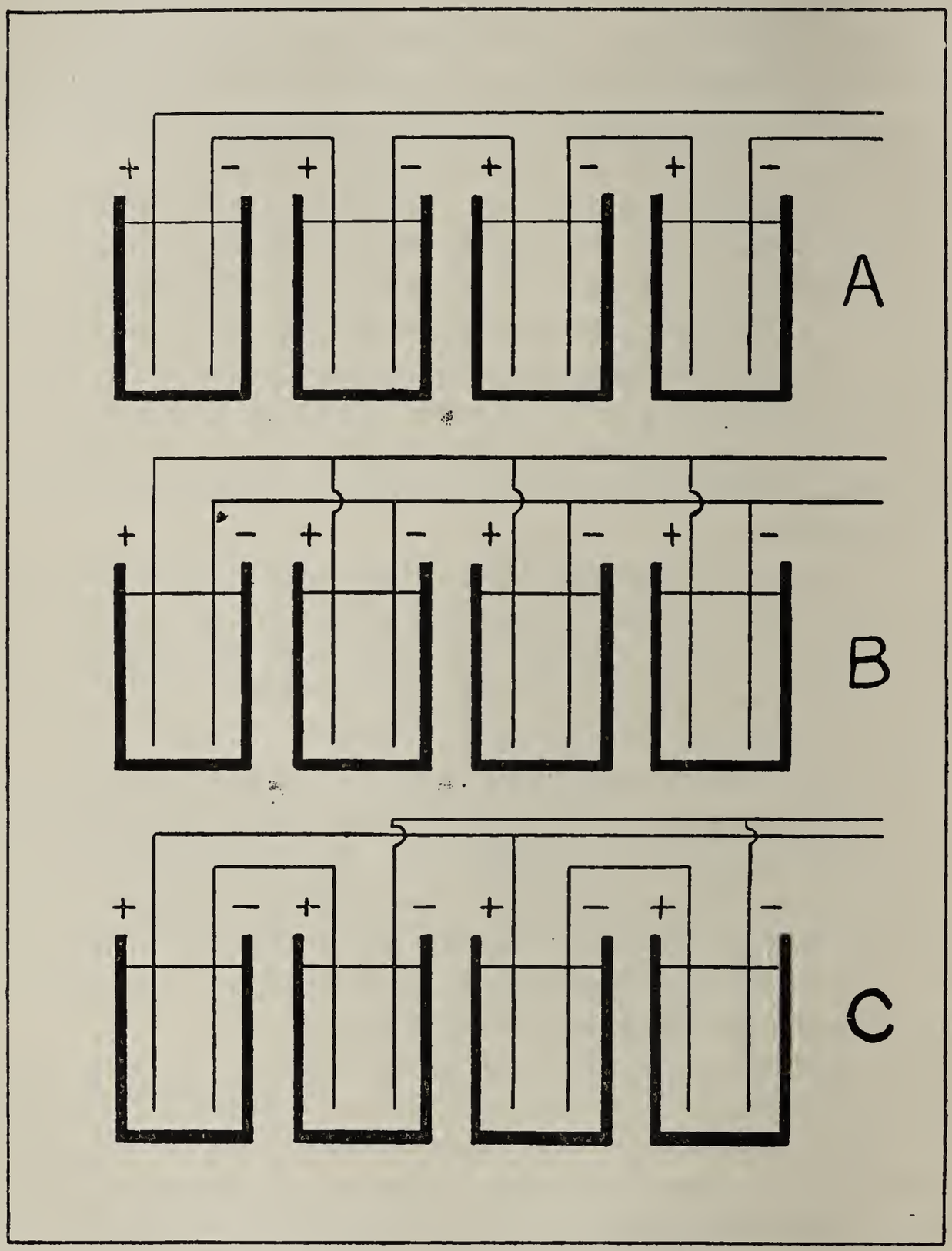


FIG. 31.—Cell coupling. A, cells coupled up in series; B, in parallel; C, in series-parallel or multiple.

will increase the voltage or pressure, but at the expense of the amperage. In each case, providing we have similar batteries, the number of watts will be identical.

Supposing each of the two cells is of 4-volt capacity, and has a discharge rate of 3 amperes. Coupling them up in parallel will give 6 amperes at 4 volts, while in series it will give 8 volts at 3 amperes, in each case showing a product of 24 watts. In other words, the voltage of any amount of similar cells is the same as the battery voltage should they be coupled in parallel, the amperage of each cell being added together, while a connection in series has the effect of adding together the voltage, this total divided into the number of watts giving the amperage. The voltage per cell depends on how and of what it is made. Some primary cells are less efficient than others according to the material used for the elements, and the electrolyte, while primary batteries as a whole give out less voltage than accumulators. As amperage may be conveniently regarded as quantity, it will be readily understood that it depends on the size of the plates.

The rate of discharge in an accumulator is described as so many ampere-hours. Thus twenty ampere-hours means that it will give out one ampere of electricity for twenty hours, or five amperes for four hours, and so on.

*The Construction of an Accumulator.*—A cell of an accumulator consisting of one negative and one positive grid will give out roughly two volts. To obtain four volts, a pressure usually demanded in electric ignition apparatus, we shall therefore require two cells coupled in series. A four-volt accumulator consists of a celluloid case, divided in the centre by a partition of similar material. This is recognized as the best substance for motor car work, although glass or gutta-percha, or, in fact, any acid-resisting material which is also a non-conductor of electricity, which can be made into a case, would do in other instances. Celluloid, however, is light, transparent, and insusceptible to vibration. The grids are furnished with lugs so that they may rest on the edge of the case, while they are made somehow shorter than the inside depth of the case, so that any paste falling out of the grids may not cause short-circuiting, that is, electrical communication between two plates of unlike polarity. Each grid is

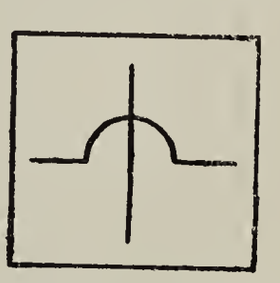

Fig. 32.—In the electrical diagrams given in this chapter when two wires are crossed in this way it indicates that there is no direct connection between them.

separated from the next one by a perforated screen of insulating material, and also kept in position by intervening ebonite pegs, so as to further guard against short-circuiting, but not to prevent a free passage of the electrolyte.

It has been found also, that it is advantageous to use an extra negative plate, which is placed on the outside of a set, so that each positive plate has a negative one on each side of it.

The plates having been arranged in the accumulator case, alternately negative and positive, each set of negative and positive plates connected together, leaving a free end of each kind at either end, an electrolyte of dilute sulphuric acid is added so as to cover the plates, but not to fill the case. A wooden lid covered with marine glue, provided with slots for the passage of the terminals and orifices for pouring in the acid, completes the accumulator, which will be probably inserted as a whole in a neat mahogany case.

*The Electric Circuit.*—An accumulator gives out electric energy so long as a closed circuit is maintained between the negative and positive terminals. Such a circuit may consist of a copper wire of any length connecting the two terminals, or the wire may be attached to any other conductive substance such as iron or steel, and so long as the other end of the wire is also connected to the intervening substance the current will flow. The earth is a conductor, and for that reason part of an electric circuit may be established by sinking the wires in damp ground, but in motor-car work this property is not made use of, as we have to deal with a moving vehicle, but the term "earthed" is used to signify a connection made to the main structure, such as the engine or frame.

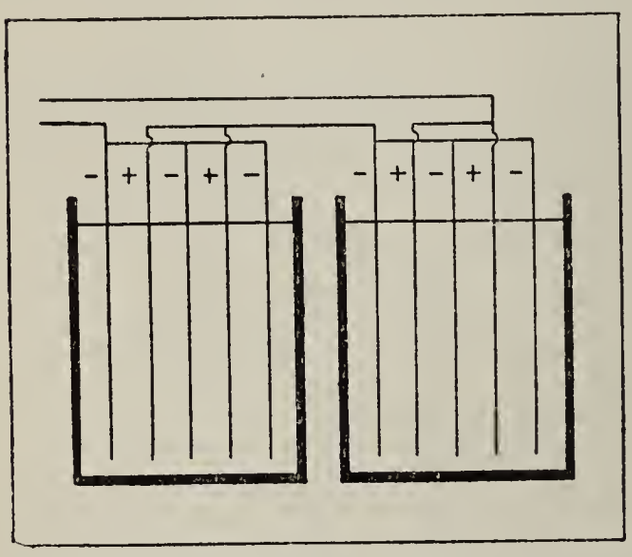


FIG. 33.—A pair of accumulators joined in series. The negative plates are coupled together in each accumulator, likewise the positive ones.

Should an insulating or non-conductive substance be inserted in the path of an electric current, it will be arrested. This property is made use of in many ways in motor-car ignition. With a switch

mounted on the dashboard the current can be cut off when not required, or re-established when starting on a journey, while mechanical devices driven from the engine continually make and break the electric circuit in order that a spark shall be made in the cylinder at the right moment.

Although the insertion of an insulating material breaks the electric circuit, yet if the insulation consists of a small gap of air, the current will jump across providing there is sufficient voltage present. This property is made use of to provide a jump spark in the various high-tension ignition systems, while if an electric circuit is suddenly broken by quickly dividing the path through which it is flowing, a spark will be made at the point of rupture. This is the principle under which low-tension ignition works. Electric ignition, whether it depends on batteries for its initial energy or a magneto, is described as either a high- or low-tension system, which, however, is more than a difference in voltage, as the apparatus used with either system is quite distinct in important particulars. Chiefly the low-tension system has one electric circuit, while the high-tension has a low-tension or primary circuit and a high-tension or secondary circuit as well. The high-tension system, with battery, was used in ordinary gas engines by Lenoir as far back as 1860; improved high-tension systems, but in conjunction with a magneto, are the fashion to-day.

The low-tension system is much simpler in several respects, and when used now it is generally coupled up to a magneto.

*Low-tension Battery Ignition.*—Low-tension battery ignition will be considered first. The four or six volts given out by a battery are quite inadequate to produce an electric current of sufficient intensity which when broken shall produce a spark hot enough for igniting purposes, unless the batteries are very large, so the voltage or tension has to be increased by utilizing the inductive properties of electricity.

*The Inductive Properties of Electricity.*—If a conducting wire be coiled into the shape of a spiral, *immediately* contact is made a momentary weaker and extra current flows in the opposite direction to the main current, that is towards the positive terminal of the battery, so that the voltage of the main current is somewhat weakened for the very brief interval during which the self-induced

current flows. Should the circuit be very quickly broken in a coiled wire, *immediately* the *break* occurs a small current is set up in the *same direction* as the main current, so increasing its voltage.

It has been found by experiment that according to the number of coils given to the wire, so the voltage is increased; in fact, each coil of wire may be regarded as a small cell coupled to its neighbour in series; and following closely the allusion we shall also find that the output in watts is not increased, so that the amperage is reduced accordingly. Thus, if we have 1000 turns of wire and the initial voltage of the battery be four volts, we shall have approximately as the output of our coil 4000 volts, and if the amperage rate is eight that will be reduced to $\frac{32}{4000} = \frac{1}{125}$ ampere, without allowing for losses in transmission.

A primary coil for use in low-tension battery ignition will have about 2500 turns of No. 14 or 16-gauge copper cotton or silk insulated wire, wound on to about a 6-in. iron core, each layer of wire as it is wound on being insulated from the next by a coating of wax or other insulating material. The object of winding the wire on an iron core is that we have a centre which will, if of soft or ordinary iron, be readily magnetized by the current passing around it, and by so doing, the magnetic field, or lines of force, emanating from the live wire will be concentrated towards the iron core and so increase the self-induction present, and consequently the voltage immediately when the circuit *is quickly broken.*

As the spark will be produced at the spot where the circuit is broken, this must be situated in the cylinder, and mechanical means are provided which shall break the contact at the right moment to ensure an efficient explosion. As there is one explosion to every two complete turns of the crank it will follow that the contact-breaking mechanism will, if connected to the engine, have to be mounted to act at half the speed, and as the intensity of the spark is in proportion to the suddenness of the break of the circuit, some quickly responsive apparatus is necessary.

Low-tension magneto ignition was at one time very much in favour, in fact the famous Mercédès car reached to a great height of popularity while fitted with this system.

*The Low-tension Magneto.*—A magneto consists of a number of hardened steel permanent magnets formed in the shape of the

inverted letter ∩. A normal compound magnet is made up of three magnets placed side by side so as to form a small tunnel, and secured to a base plate, over which is directly superimposed a second set of three magnets screwed to the lower set. Inside the tunnel, at the bottom on each side, are fixed the soft iron pole pieces, which are curved on their inner side so as to give a clear passage for the revolving armature, or soft iron screen, according to the principle used, such clearance being uniform, and very small, in fact about $\frac{1}{100}$ of an inch.

In the same way that the current passing along a conducting wire is not confined to that wire, but passes into the atmosphere surrounding, so the magnetic field surrounding the poles of a magnet consists of lines of force converging in all directions. These lines of force are cut by the winding on the armature when it moves, thereby inducing a current of high voltage in the wire, such current being concentrated by the soft iron core on which it is wound.

The armature is mounted on a spindle which runs in suitable bearings at each end, one end being devoted to driving the spindle, and the other to leading away the current generated to the igniter in the cylinder head. The armature commonly used is known as the Siemens type, and is of H section, the sides of the letter being rounded on the outside, and the cross bar forming the main bearing for the winding.

The lines of force coming from the poles of the magnets being thickest at the base between the arms of the ∩, it is therefore the best place for the armature, as the voltage of electricity is in direct proportion to the number of lines of force cut. It is also essential that there should be as little space as possible between the revolving and stationary parts, as the strength of the induced current is in the inverse proportion to the clearance.

In a low-tension magneto the central portion of the armature having been wound longitudinally with fairly coarse wire, and the naked iron having first been insulated with silk ribbon, treated with shellac, one end of the wire is bared and fastened by a small screw to the body of the armature. After the length of wire has been wound on, each layer being insulated from the one below it by a coat of shellac, the end is brought out to the spindle on

the current collecting side. This spindle has an insulated centre, through which passes a copper wire. The inner end of this wire is coupled up to the free end of the armature wire. The outer end of the spindle wire is splayed out into a small knob so that it may readily have electrical contact with a similar projection mounted in the end bearing. This second knob is kept up to its work by a small spring, and is in direct communication with a terminal to which is attached the wire leading to the igniter in the cylinder. The end of the spindle and the end bearing, though in electrical contact in the centre, where the two knobs meet, is insulated at all other points of contact, so that all current coming from the armature wire passes only to the contact of the bearing, and so through the terminal wire to the combustion chamber. One bearing being given up to leading away the induced current, the other one nearest the engine is devoted to driving the armature, or if this is of the stationary type, then it transmits motion to the screen, either revolving it completely or oscillating it backwards and forwards, according to the pattern of magneto under consideration. The current is induced in the winding of the armature, by reason of the revolving armature cutting the lines of force in the magnetic field. The same result is brought about should the armature remain stationary and the lines of force be alternately shielded from or exposed to the armature winding by means of an interposing screen, which being of soft iron concentrates the lines of force upon itself.

It has been shown at the beginning of this chapter that an engine running at one thousand revolutions per minute, requires half as many explosions in that time for the working of the piston. Taking a recently designed engine, one finds that it has a stroke of 127 mm. or 5 ins., from which it will be readily calculated that the piston travels 2000 × 5 ins. or nearly 280 yards in a minute.

*Timing the Spark.*—Although electricity acts rapidly, and it is an easy matter to produce sparks much quicker than the eye can count, yet the resulting explosion develops much more slowly. If the explosion were instantaneous, it would be quite correct to fire the charge immediately the piston had reached its highest point in the cylinder, but if this were done with a high-speed engine, the result would be that the explosion would not be completed until the

piston was moving down the cylinder again, thereby increasing the area of the combustion chamber, giving the gas more room to expand naturally and gently before being finally expanded with violence by the electric spark. The combustion chamber thereby enlarged, the force of the resulting explosion is proportionately lessened, in fact, "late ignition" has taken place, or the spark has been "retarded."

To get over this difficulty, it is arranged that the electric spark shall enter the combustion chamber before the piston reaches the top of its stroke, but the ignition must not be advanced too much, otherwise there will be danger of the full force of the explosion developing before the top of the stroke, and so tending to push the piston back again. On an average the spark enters the combustion chamber when the piston has about another $\frac{5}{8}$ of an inch to travel upwards.

The explosion will take place more rapidly if the spark is hot, while a powerful ignition will fire a wider range of mixtures, so that a very fine adjustment of the carburettor is not called for.

Having recognized the necessity for timing the ignition, we will now consider the means provided to fire the charge. With the low-tension system it will be remembered that use was made of the property of an electric current which is exhibited when that current is broken. The current from the battery having been intensified by traversing the primary induction coil, or the wiring on the armature of the magnets having been charged by cutting magnetic lines of force proceeding from the magnets, the tension so stored up is sufficient to produce a spark across a small gap or air space in the circuit, the violence of the spark being in proportion to the pressure of the current and the quickness of the break.

*The Low-tension Igniter.*—The breaking of the circuit is done by a contact breaker. It will be better, however, to refer to it as an igniter, so that the terms contact breaker and contact maker can be reserved for their particular uses in a high-tension system. As the igniter has to act at half the speed of the engine, it is generally found convenient to utilize the valve cam shaft for that purpose, or a special two to one gear may be provided. Into the combustion chamber wall is screwed an insulated plug (not to be confused with

a high-tension sparking plug), through the centre of which passes a copper wire carrying the current from the generating source. This has a tip of platinum at the end, being a substance which will not readily oxidize under the heat of the spark, and therefore keeping clean, and providing proper contact on every occasion. Close to the plug is also inserted into the cylinder wall a small lever working on a pivot provided at one end with a platinum point. When these two points are in contact the current flows through the circuit, but directly the lever is moved separating the platinum points the small distance necessary, a spark immediately occurs. Normally the lever is kept up to the contact position by a coiled spring, and is pushed out of contact by a rod acting on the end of the lever, the rod being raised by a projection or cam mounted on a shaft driven by the engine. After being raised, the rod is brought down smartly again by another coiled spring, which has been compressed during the time the rod has been pushing the platinum points apart.

Instead of a rod end pushing the end of the lever, a small spring hammer may be tripped up by a suitable projection, a cam being used as before to impart motion. The spring used should be strong, and the moving parts light, so that they are responsive.

*Variable Low-tension Ignition.*—With a low-tension ignition, the time of the ignition may be varied by suitable mechanism acting on the cam, which causes the points in the cylinder to be separated early or late in the cycle of operations. Being directly coupled to the engine, the number of sparks naturally increase with the rate of the crank shaft, but whatever the speed, the explosions still take about the same time to develop, therefore it is desirable to allow the spark to be made proportionately earlier, so that the full force of the explosion still develops at the top of the piston stroke.

*The Rise and Fall of Magnetic Induction.*—In a low-tension magneto system advantage is taken of the position of the armature with regard to that of the poles of the magnets, and consequently, the line of force, in order to arrange the normal ignition point. When the curved sides of the armature are lying upright in the shaped recesses of the pole pieces, the magnetic lines of force pass straight through the core of the armature. As soon as the armature commences to turn, the lines of force are raised at one end, pass through the now oblique core, and so out at the lower end of the

other pole piece, the directions continually altering until the armature is at right angles to its first position, when the lines of force now pass across the curved ends of the armature only, leaving

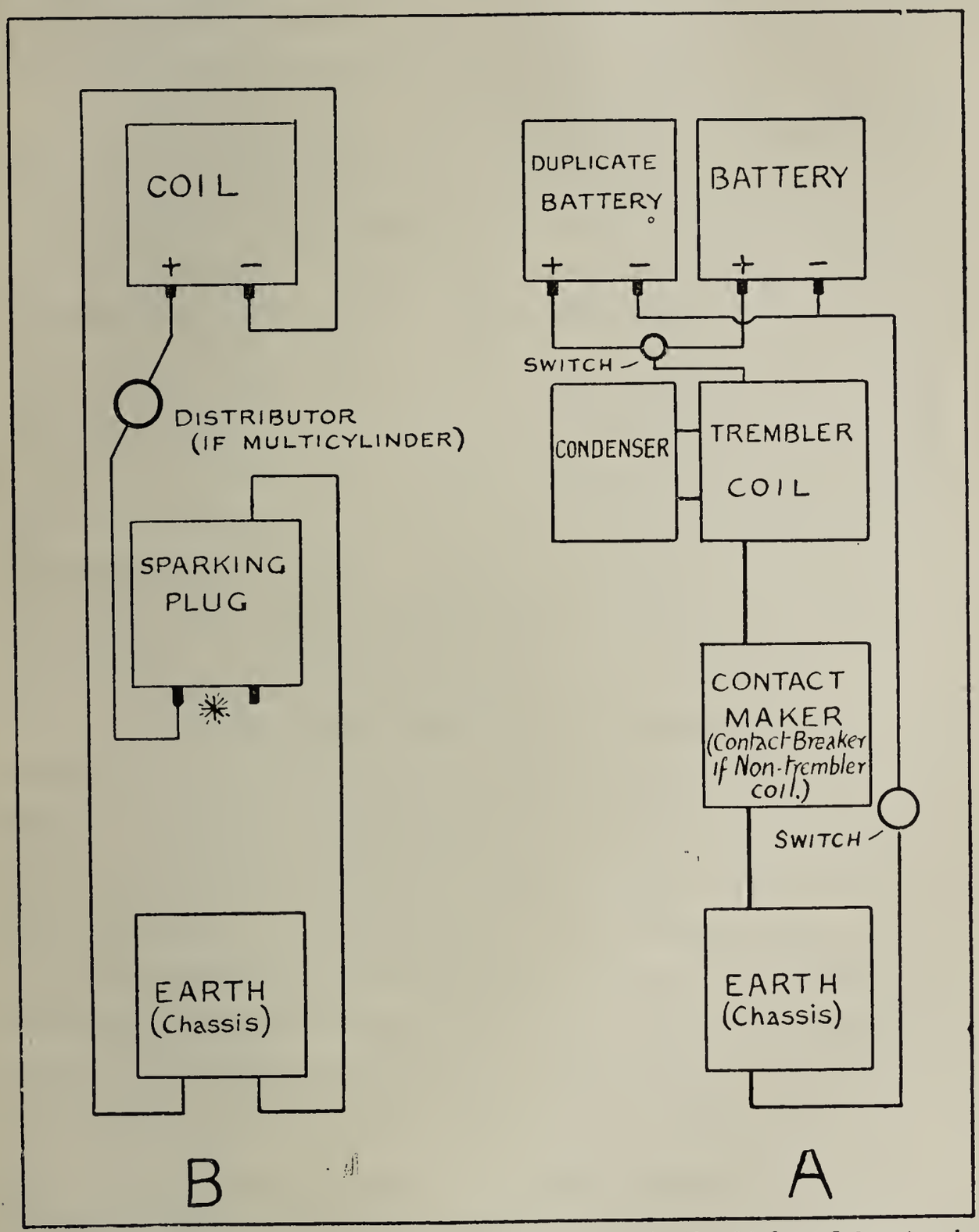


FIG. 34.—Diagram showing the path of the current in the high and low tension circuits. A, low tension, or primary circuit; B, high tension, or secondary circuit.

practically free from magnetic induction the winding on the core, so that no electric current is given out. The magnetic induction is greatest just when the circuit is being broken, that is, just when

the edge of the armature has left the edge of the pole piece, and, generally speaking, when these points are separated $\frac{1}{10}$ in., it is arranged that the striker or lifter, actuated by the cam shaft, separates the platinum points in the cylinder. The contact may be broken in the cylinder by a special magnetic plug, as well as the mechanical system already described.

So far we have only taken into account the firing of one cylinder. Two, three, four, and six cylinders are commonly in use, especially the two last numbers. In a multi-cylinder engine all the plugs are connected together, while each lever or striker of the igniters has a separate cam on the same cam shaft. If we look at this cam shaft from the end, say, in a four-cylinder engine, at the various projections of the cams, it will be noticed that they are arranged equi-distant as around the circumference of a circle, while with a six-cylinder engine we should produce a hexagon if the centres of the cam projections were joined. With a magneto, be it low or high tension, the armature is geared to the engine, according to the number of explosions required per crank shaft revolution. This equal spacing around a circle is also utilized in high-tension devices when the current has to be distributed to the various cylinders or to the coils, when more than one is used.

*The Low-tension Circuit.*—The electric circuit of a low-tension ignition system is as follows: Having left the magneto or battery and primary coil, it passes to the insulated plug in the cylinder head, across to the striker, and through the metal of the engine case; then, if a magneto is the generative source, the current finds its way back to the armature winding at once through the engine bearings, which carry the shafts and wheels driving the armature, but if a battery, the current goes to the frame or engine, where it finds the earthed wire of the battery, and so back to the negative terminal.

*High-tension Ignition.*—The high-tension system is that generally adopted on cars of to-day, and usually a magneto is the generator, while on many cars a high-tension battery system is also employed as a duplicate, or the two varieties may be independent for only a portion of the secondary circuit.

In a high-tension system we have to provide a low-tension or primary circuit as well as a secondary one of higher tension. The

primary one, when broken suddenly, promotes the s[illegible] self-induction, the secondary being wound over the primar[illegible] much greater length, both circuits here being in coils. The se[illegible] circuit being connected to the sparking plug, the explosions [illegible] controlled according to when the primary circuit is broken.

This is carried out by a contact-breaker, driven from the engine, which has a revolving cam which separates at the proper intervals two platinum points, both being connected in the primary circuit.

One of the essential things to remember, with any type of ignition, be it low or high tension, is that the primary circuit has to be broken suddenly to produce the necessary spark. In low-tension ignition it is broken in the cylinder direct; in high-tension ignition it is still broken in the low-tension or primary winding, only the break is used to induce a current in the secondary circuit and force a spark across the small resisting air gap between the sparking plug points, while the spark which is formed by the breaking of the primary circuit is absorbed until the circuit is made again by a contrivance called a "condenser," which is a shunt in the primary circuit, and is a siding, or rather a loop-line, connected at each end with the main line of the primary circuit.

*Non-trembler Coils.*—Coils which are used to generate a secondary current may be (1) plain or non-trembler coils, or (2) trembler coils. The former consists of a soft iron core made of a tight bundle of wires, on which is wound a few layers of thick wire, forming the primary winding, over which is superimposed a far greater number of layers of fine wire, forming the secondary winding. The first layer of wire is insulated from the core, each coil from the next, and the primary from the secondary winding. One end of the primary winding is connected to the positive terminal of the battery, while the other end is connected to the contact breaker, which is connected to earth. The circuit is then taken up by the earthed wire of the battery, which leads to its negative terminal.

Contact breakers require platinum points, which from time to time require attention, to preserve their proper contact.

*Trembler Coils.*—With a trembler coil the circuit breaking is transferred to a contrivance called a "trembler," working on the end of the coil core, while the engine, instead of driving a contact breaker, as with a plain coil, drives a contact maker.

makers are, broadly speaking, of the wipe type, in which conducting material bears against metal segments let in lar intervals into an insulated revolving disc. These two rts may be fixed so as to be slightly apart nominally, being brought into contact by a cam or similar tripping device working a lever which has one of the points connected to it.

A trembler coil is the type generally adopted with accumulator

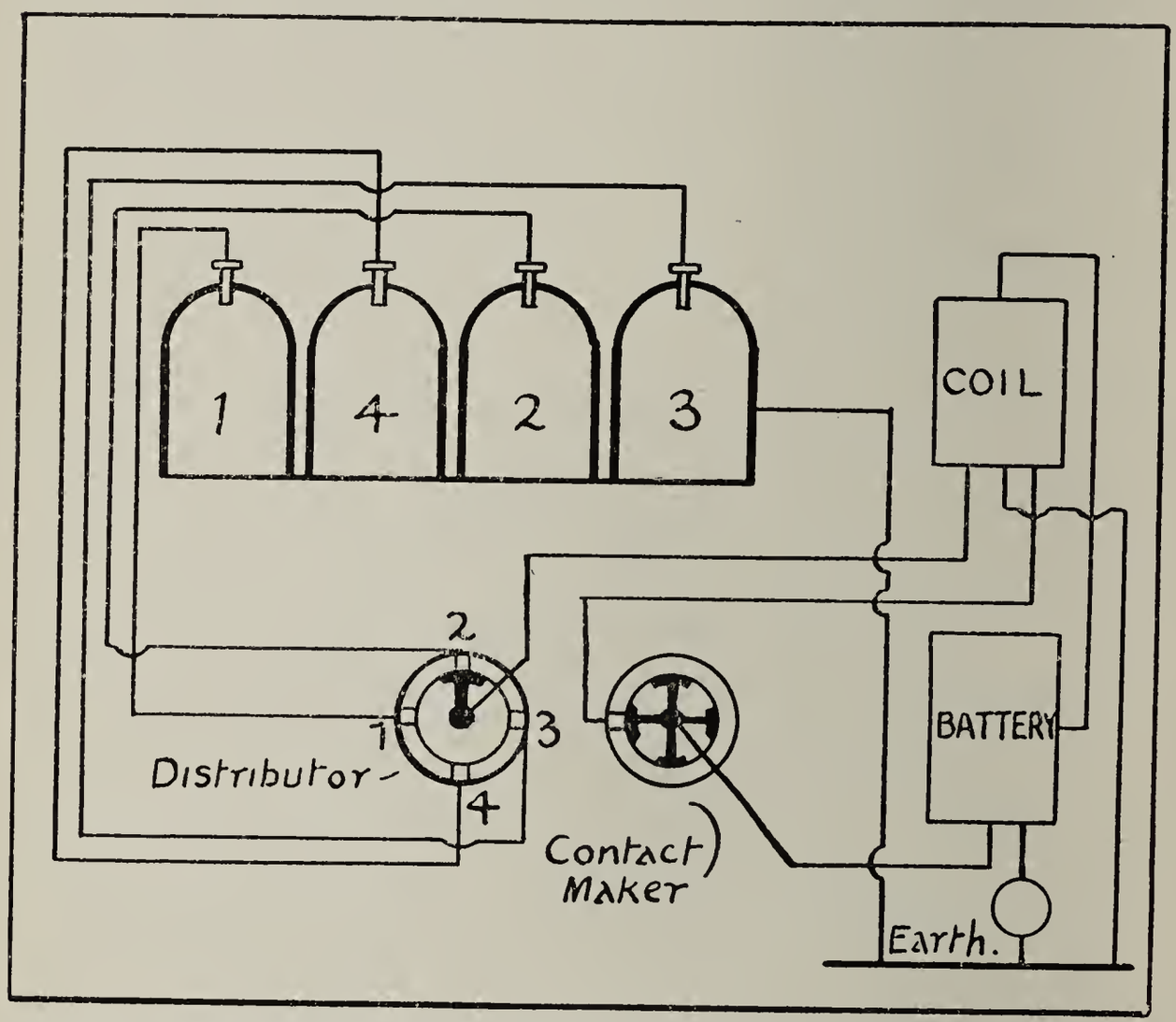


FIG. 35.—Wiring diagram of a four-cylinder engine with high-tension battery and coil system. The numbering indicates the order of firing.

ignition. When the primary current passes round the core of the coil, the core is magnetized. The magnetized core attracts to it a piece of soft iron attached to the under side of the trembler blade, drawing it down and at the same time separating a pair of platinum points, thereby breaking the primary circuit, so that the current is induced in the secondary circuit and a spark jumps across the points of the sparking plug. The trembler blade, however, only

touches but momentarily the end of the magnetized core, for the platinum points of the trembler, which are part of the primary circuit, being separated, the circuit is broken, and consequently no *primary* current flows in the coil, and therefore the magnetization is arrested, so that the trembler blade (which is practically a plate spring) is almost immediately released, only to come again in

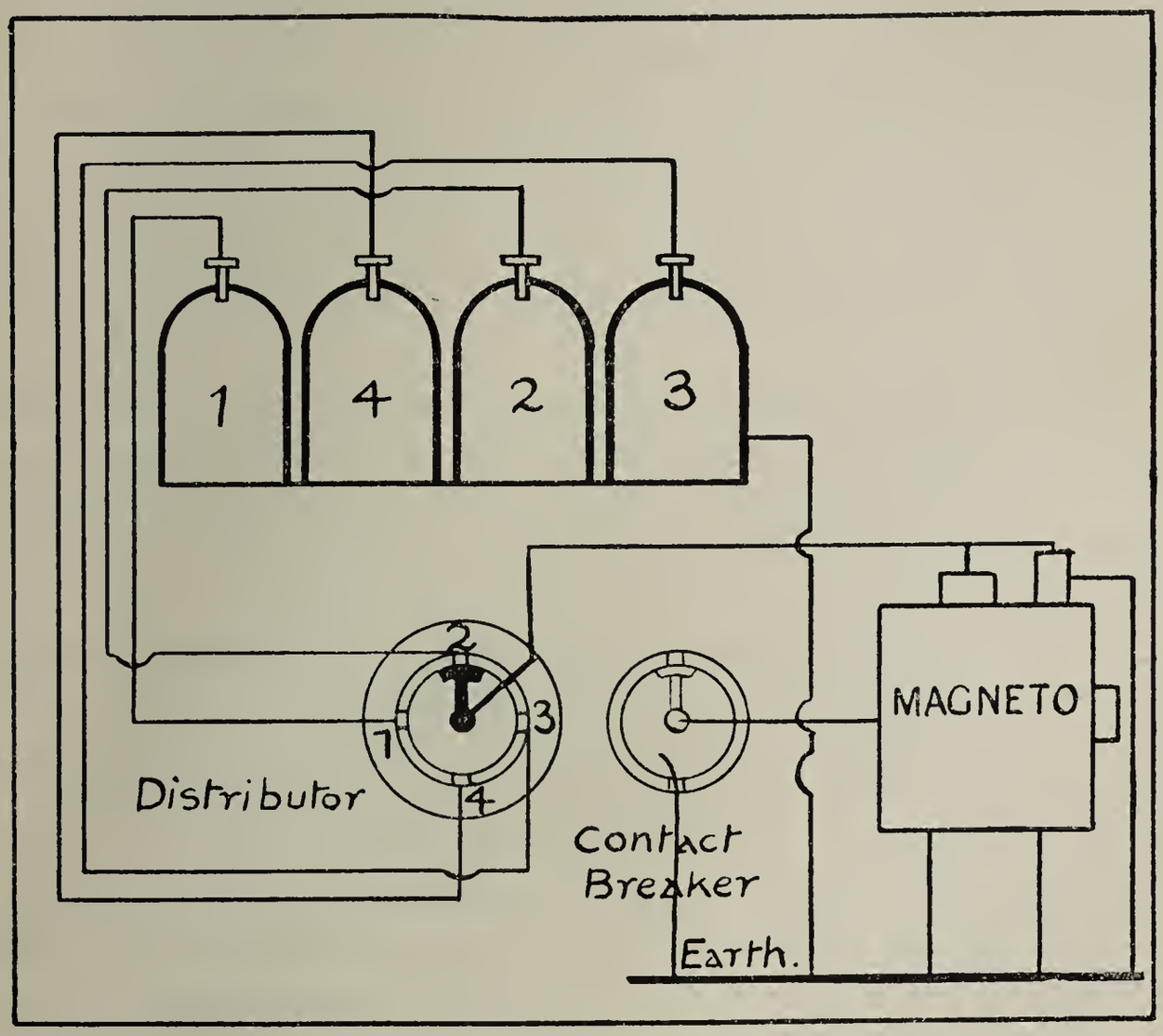


FIG. 36.—Wiring diagram of a four-cylinder engine with high-tension magneto.

contact with the other platinum point, making the primary circuit again and drawing the trembler blade down once more. This repetition of magnetic attraction and electric circuit making and breaking is kept up at a high speed, while the contact is being made by the engine-driven device, causing a stream of sparks in the combustion chamber.

*The Condenser.*—A condenser is used to absorb the current when it is broken in the primary circuit, as with a plain coil, the connection being made to each side of the trembler points instead

of a similar arrangement between the points of the engine contact breaker.

A condenser consists of a number of alternative sheets of tinfoil and waxed paper, or other substances which are respectively of insulating and non-insulating material, and can be at the same time prepared in very thin sheets free from holes. From the electrical point of view, any similar arrangement of two conducting bodies separated by an insulator is a condenser. The Leyden jar is a familiar instance in which glass forms the insulator or dielectric, and this apparatus forms an essential part of the Lodge ignition.

A condenser is necessary in all high-tension systems, and, where no separate coil is used, as in many magneto installations, it will be found lying near the contact breaker or primary winding on the armature.

The low-tension system requires special designing of the general engine arrangement, but the high-tension ignition merely requires a hole in the cylinder head for the sparking plug, although it makes a more compact job in many cases if a special shelf is provided for the magneto.

*High-tension Magneto Ignition.* — The high-tension magneto embodies within itself not only both primary and secondary windings, contact breaker and high-tension distributor, but there is no necessity for a coil, no recharging of accumulators, or replacing of dry cells required. It calls for a larger initial outlay, but this is more than compensated for by its convenience; any derangement of the magneto mechanism is very unusual, and any parts which do require periodical attention are easily accessible and adjusted. Bearing in mind what has been said with regard to low-tension magnetos and high-tension battery systems, it will be a simple matter to follow the principles under which the high-tension magneto does its work.

There is an armature furnished with a primary winding as before, which is in connection with a contact breaker mounted just in front, and insulated from the pole pieces. Connected to each side of the contact breaker is a condenser. The secondary winding is wound over the primary as in a coil, and the induced current, which is set up every time a break is made by the contact breaker, is led to (if it is a multi-cylinder engine) a high-tension distributor,

which, for the sake of compactness, is mounted directly over the contact breaker, and in fact geared to it by means of toothed wheels, so that the number of low-tension breaks corresponds to the required number of high-tension sparks for every two revolutions of the crank shaft. The magneto is timed by moving one portion of the contact breaker so that the contacts are broken earlier or later with regard to the crank shaft revolutions.

The longitudinal section of a complete high-tension magneto may at first sight appear complex, but bearing in mind the above principles of its working, and that the electric circuit if required to keep along a certain path must always pass along a road of conducting material, and must be prevented from straying when passing by another conductive substance by proper insulation, and that magnetic influences are unaffected by non-magnetic metals, which at the same time are electrically conductive, the examination of any type of magneto becomes at once much simplified. The following is a description of a Bosch high-tension magneto.

*The Primary Circuit of a High-tension Magneto.* — The main structure consists of two sets of three steel ∩-shaped permanent magnets, one set placed over the other, the upper one being slightly shorter. To the inside at the bottom of the lower and under set of magnets is screwed on each side a pole shoe, each shoe being drilled underneath so that a non-magnetic metal baseplate may be screwed on from underneath to them. It is usual to speak of the front of the magneto as the side nearest the engine and that which is driven, while the back is the side from which the current is led away to the cylinders.

The front end plate, which is provided with a ball race and lubricating arrangements, and pierced for the armature and spindle, is attached to the magneto structure by long screws passing into the pole shoes, and short ones into the base plate. The rear end plate is similarly attached to the pole shoes and base plate, but is twice the height of the front end plate, as provision has to be made not only for the armature spindle and contact breaker bearing below, but above has to be fixed the high-tension distributor. The rear end plate in itself has no bearing for the armature, so a special cover with ball races and their accompanying lubricating devices is screwed to it.

The next important portion after the magneto and end plates is the armature. This has the two windings coiled on in the centre and kept securely in position, so that the windings shall not be moved by centrifugal force, by a few turns of wire running in two grooves at right angles to the direction of the armature winding.

The armature complete with its two windings has a portion of the spindle left bare and a gear wheel is keyed on to it over the front end, so that it can be driven from the engine. If a single-cylinder engine was under consideration, this pinion would be so geared that the armature would be driven at cam shaft, or half the crank shaft speed, one maximum armature position being wasted; for twin-cylinder engines with cranks set at 180°, it would be the same; for two-cylinder engines with cranks at 180°, crank shaft speed; with a three-cylinder motor, the armature is run at three-quarters crank shaft speed; with a four-cylinder, same as crank shaft speed; and for a six cylinder it must be run at one and a half times the speed of the crank shaft. To sum up, two igniting sparks are available for each complete revolution of the armature, and unless we are dealing with a special type of engine the speed necessary can be directly calculated from the number of cylinders. Thus in a six-cylinder engine there are six explosions in two complete revolutions of the crank shaft, and as there are two sparks per revolution of the armature, it naturally follows that the armature must move $\frac{6}{2} \times \frac{1}{2}$, or $1\frac{1}{2}$ times as fast as the crank shaft.

To return to the description of the armature. Next to the driving portion of the spindle, and nearer the centre of the armature, is the other portion of the ball race, which engages with the corresponding parts mentioned with respect to the front end plate. Still working further towards the centre, we find the slip-ring on which the carbon brush collecting the high-tension current bears, then comes the front armature disc, which is of non-magnetic material, and grooved or otherwise accurately fitted to one end of the soft iron armature itself.

Passing across the windings, we next come to the other armature "disc," which is made rather in the shape of a socket, the bottom of which forms the rear armature disc, while the space left inside is set apart for the disposal of the condenser, this being a convenient position, as the contact breaker, to which it must be connected

directly by at least one wire, lies close to it. The complete condenser with its connections having been placed in this recess, it is found that the exposed side has a brass plate attached to it. This plate carries one end of the primary winding, and it is pierced in the centre, so that a screw which is long enough to pass right through the contact breaker and hold it in position, may transmit the current to one platinum screw of the contact breaker. Between the back of the contact breaker and the brass plate is a ball race and pinion, the latter being the nearer to the centre of the armature. The ball race engages with its corresponding portion on the back end plate already described, while the pinion is utilized to transmit motion to the high-tension distributor. As the long screw which holds the contact breaker passes right through the centre of the back end of the armature spindle, it therefore passes also through this ball race and pinion.

The centre of the contact breaker is also the centre of the platinum screw block. This has a long platinum screw running through it. At the point of contact a shorter platinum screw touches it, this second screw being fastened to a cranked lever which as it travels round it is twice tripped up by fibre rollers, thereby providing the necessary breaks. These two fibre rollers are fastened on each side of a circular flanged piece attached to the back end plate, and around the contact breaker, round which it can revolve so as to form a timing device.

*The Secondary Circuit.*—We will now leave the primary winding mechanism, and consider the path taken by the secondary circuit, which is set up when a separation takes place at the platinum points of the contact breaker. The secondary current is conveyed to the slip ring at the front end of the armature spindle. From here it is conveyed to a carbon brush, which is held in position by being screwed into a boss on a dust cover plate, which is immediately above the armature. From the top of the brush, which is insulated from the dust cover by a suitable bushing, it proceeds to a bridge or small metal plate, having one end turned up at right angles. This turned-up end carries another brush pointing at right angles to the first one, and towards the back end of the magneto. The end of this horizontal brush is in contact with the rotating piece of the high-tension distributor, both of

which, as they carry a high-tension current, are heavily insulated. On the back end of the rotating piece (just above the contact breaker) is fixed at right angles a third carbon brush, being the only movable one. This as it revolves comes in contact with metal segments in a fixed distributor disc, the number of segments being arranged at regular intervals and in number according to how many cylinders there are in the engine. From these metal segments is led away a heavy insulated high-tension wire to each sparking plug, the junction at the magneto end being made by suitable sockets.

Over the contact breaker fits a brass cap, which is kept in position by a small plate spring bearing upon it, the other end of which is fastened to a triangular clamp, which in turn holds an ebonite cover over the high-tension distributing disc.

The secondary circuit is as follows: Starting from one end of the primary winding, the other end of which is earthed to the armature, it proceeds to the slip-ring, then through three carbon brushes to one of the metal segments of the high-tension distributor. From this it proceeds to the sparking plug across the points to the body of the engine, and so finding its way back to the armature, as this is in metallic, therefore electrical, communication with the cylinder head.

*The Safety Spark Gap.*—The efficiency of almost any ignition apparatus depends in a great measure on the care taken of the insulation. This is specially so in the high-tension circuit between the armature and the sparking plug. Should a cable carrying current to a plug become broken or disconnected from any cause, the uncontrolled high-tension current might do considerable damage to the magneto. To prevent this a safety-spark gap is arranged immediately after the brush which bears upon the slip ring. The current when passing through this is earthed *viâ* the armature dust cover in which the safety sparking arrangement is secured.

The ignition is shut off when required by an insulated wire being attached to the nut which holds down one end of the spring holding the brass contact breaker cover. These being all of metal and the wire attached to a switch, this has only to be manipulated to short circuit the primary current through the switch to earth.

# CHAPTER XIX

## *THE COOLING OF THE CYLINDERS*

*The Necessity for Cooling.*—Some means of cooling the cylinder walls is necessary, owing to the great heat generated by the combustion continually going on inside, otherwise the walls would soon become incandescent, and the charge of gas would become ignited before the proper time; also the lubricating oil, if heated above 600° F., would become thin and charred or carbonized, so as to be useless.

The cooling may be effected by means of a circulation of water, which enters the cylinder jacket at the bottom, then rises to the top, and is conveyed to a radiator, and from thence back again to the bottom of the jacket. The whole of the water soon becomes warm after a short running of the car; it enters the bottom of the cylinder jacket well below boiling point, and leaves the top a little below 212° F. In passing through the radiator a greater portion of the heat is dissipated by reason of the water-heated pipes coming in contact with a large body of air.

The circulation of water may be natural (thermo-syphon), or forced by pump.

*The Thermo-syphon System.*—In the thermo-syphon system advantage is taken of the fact that water, as it becomes heated, expands, and is therefore lighter than an equal body of cold water, consequently it rises. The system is then arranged so that the bottom of the radiator is somewhat high in comparison with the cylinder jackets. The natural circulation requires a free flow, so that pipes should be as large (not less than $1\frac{1}{2}$-ins. bore) and as smooth as possible, and free from sharp bends. This system, if well designed, has the advantage of simplicity, seeing that no pump is required, and that the cooling is not dependent on the rate of

movement of the crank shaft. More water, however, is required, and the system is, on the whole, slightly heavier than the forced circulation.

*The Pumped Circulation.*—With the pumped water circulation, a pump is situated near the lowest and coolest part of the system, the

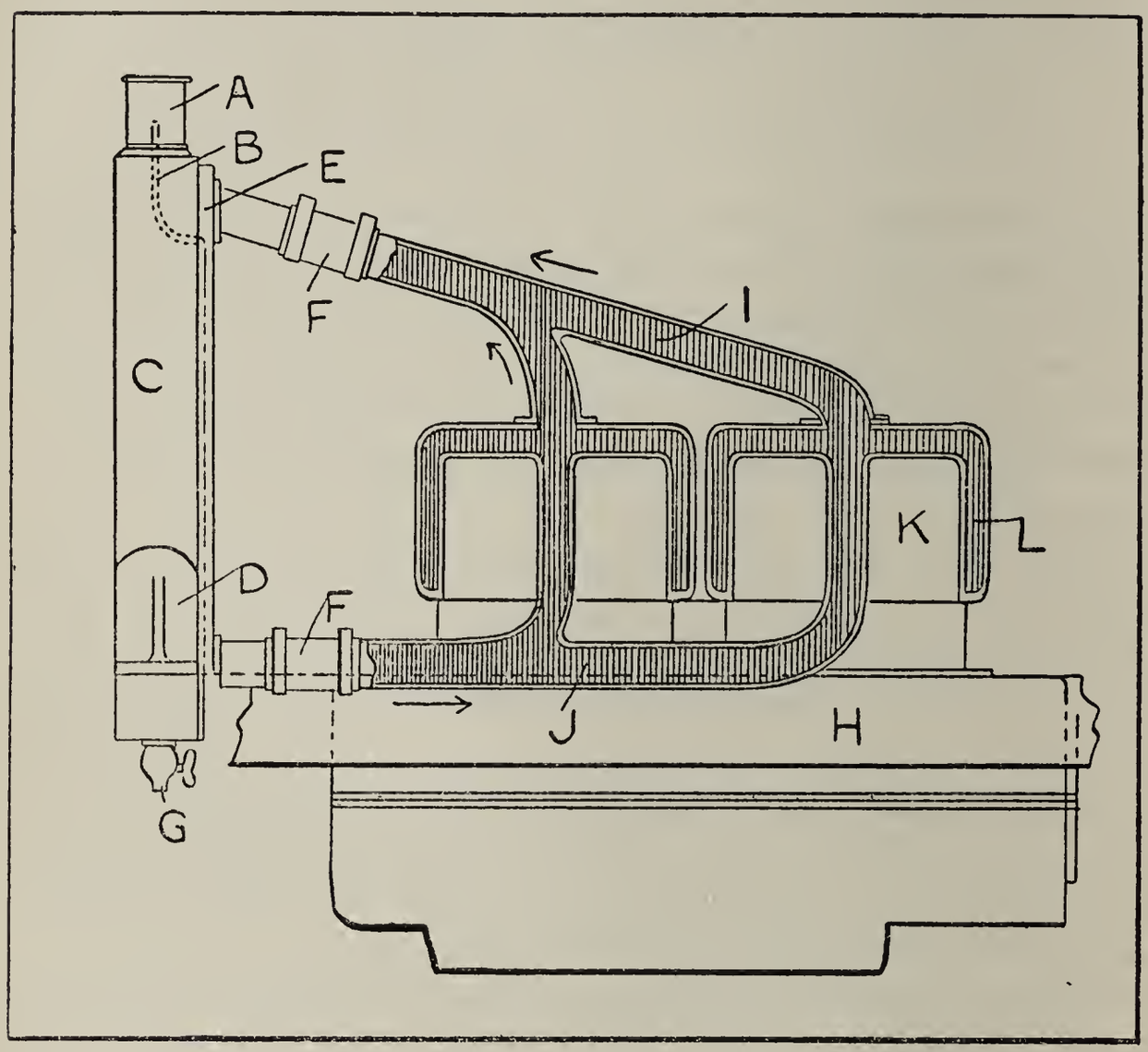


FIG. 37.—Cooling arrangement of cylinders (natural circulation). A, radiator cap and filler; B, overflow pipe; C, radiator; D, bracket for bearing on chassis; E, flange for bonnet; F, hose connections; G, drain cock; H, crank case; I, return pipe to radiator (heated water); J, pipe from radiator to jackets (cooled water); K, cylinders; L, water jackets of cylinders. The arrows indicate the direction of the flow of the water.

whole radiator can be lower in respect of the cylinder jackets, and the cooler water enters at the bottom of the jackets, as with the natural circulation.

The pump used may be of the centrifugal or positive throw type, and will be revolved by means of a small shaft and pinion,

geared to the pinion at the end of the crank shaft. It was only in the older makes of cars that the pump was friction driven off the flywheel. A centrifugal pump consists of an arrangement of curved blades, usually six in number, called an impeller, rotating from a centre mounted in a closed chamber. The water is caught up by the blades as they revolve (usually $1\frac{1}{2}$ times the engine speed) and forced out into the discharge pipe. The pump should have ample wearing surfaces, so as to resist wear and prevent leakage. With a positive-throw pump the water is forced in definite quantities per revolution, either by means of a spring-mounted eccentric, or intermeshing gear wheels. In the eccentric type a disc is thrown against the inside of the pump casing as it revolves, so forcing the water out, while with the gear type each tooth acts as a tiny bucket.

The piping used with the water circulation is usually of copper, joined up by means of rubber hose, so that the unions are elastic and will withstand vibration. A drain cock should always be provided at the lowest point of the system, so that the water may be easily emptied when required to clean out the piping, or should the car be left in a cold place where the water is liable to freeze.

*The Radiator.*—Perhaps the most delicate part of a motor car is the radiator. The ideal sought after is a maximum of surface exposed to the air, combined with a minimum of water contained, compactness, and light weight. The older pattern of radiators consisted simply of a long water pipe bent into a coil, and surrounded by gills, so as to increase the surface with which the air might come in contact. This pattern was heavy and bulky in proportion to the service rendered, and when disposed on either side of the engine two sets of piping were necessary.

Improved types of gilled radiators are now made, but the piping is smaller, and the system of increasing the surface by means of gills is more effective. This style is lighter, less expensive, and slightly less effective than the type next described.

The popular type of to-day is the honeycomb radiator, in which the water passes *between* a large number of short pipes or tubes of hexagonal, round, or square section. Some three or four thousand of these small pipes are arranged in a suitable frame corresponding to the design of radiator, and spaced by means of wires, the gauge

of wire deciding the water spaces. After assembling, the whole is pickled in acid, and then dipped, front and back, into a bath of special solder, thereby plugging up the space between the pipes. The honeycomb is mounted in a metal frame for attachment, generally between the side members of the chassis, and to the top is connected a small header tank and a similar one below, to which the inlet and outlet water pipes are attached securely by the usual hose connections.

The tubes may also be separated by being swaged or slightly enlarged in section at each end, thereby leaving the necessary water spaces in between.

The large number of soldered joints render this type of radiator somewhat delicate, and it should be mounted on rubber or felt pads, and, if possible, some slightly oscillating form of mounting, so that it may give with any whip of the frame. The radiator is now often mounted on the dashboard, where it is out of the way of possible collisions, does not influence the size of bonnet required, and allows of a more accessible engine. The dashboard position allows of a higher radiator, which, as pointed out, is desirable with a natural circulation.

*The Fan.*—A fan is usually adopted to suck the air through the radiator. This is mounted behind the radiator, preferably on the cylinder casting, and driven by a belt from a small pulley worked from the crank shaft. The fan should be mounted eccentrically, or by other means, so that the slack of the belt may be easily rectified.

When the radiator is on the dashboard, the fan is usually incorporated in the flywheel, and the bonnet and undershield made comparatively airtight.

*Air Cooling.*—The simplest form of cooling is by direct contact with the air, the cylinder heads being provided with gills or flanges, as used with success on cycle engines. This system has been experimented with more largely in America than in Great Britain. The difficulty is to get the stream of air to circulate continually past the heated surfaces, and this has been assisted by means of various mechanical devices.

This system is worthy of more interest than has been meted out to it, as there is considerably less complication and weight; freezing is impossible, but, like other things about cars, it is not fashionable.

Effective air cooling would seem to require the isolation of the valves from the cylinder casting, so that the air could circulate all round them. The piston-valve engine is a type which assists this object. As with water circulation, the air should be let in at the bottom of the jacket, if one is provided, and allowed to rise to the top.

*The Water Used.*—The water used with a cooling system must be as soft as possible, and free from visible sediment, so as to keep the piping, especially in the radiator, clean and free from blockage. Core sand may work into the water from the cylinder jacket casting, and overheating has to be avoided by keeping the front of the radiator clean, therefore it is often a good plan to protect it with a small mud-shield. This question suggests a further advantage of the dashboard radiator.

# CHAPTER XX

## *TRANSMISSION*

*The Object of the Flywheel.*—The internal-combustion engine develops useful power only at a comparatively high speed, therefore the crank shaft has to be coupled to suitable gearing, so that its rotative speed may be utilized under all conditions of the car's work. The impulses given to the crank shaft by the descending pistons increase in smoothness according to the number of impulses taking place during one revolution. Although the pistons may be balanced exactly as regards weight, it is necessary, in order to ensure smooth running of the engine, that a flywheel shall be provided, which acts as a reservoir of energy and creates, as near as possible, an unvarying turning movement on the crank shaft instead of a series of jerks. The flywheel is also used as the female portion of the clutch, which is described later on.

The flywheel has more work to do the less cylinders there are, and in a single-cylinder engine it will have to provide the momentum to carry the crank shaft round one and a half times in every two revolutions, or during three out of the four operations of the Otto cycle. In a four-cylinder engine there is an explosion every half-turn, so that its function is of less importance, and, for that reason, the flywheel could be made lighter in a multi-cylinder engine; but it must be of sufficient diameter and surface to accommodate the male portion of a cone clutch or other variety used, and allowance is made for misfiring.

The size of the single-cylinder split flywheel governs the dimensions of the crank case in which it is contained, and it has to be kept within reasonable limits in both single- and multi-cylinder cars, as a large flywheel means weight and vibration when the car is standing.

*The Clutch in Driving and Gear Changing.*—The clutch provides a convenient method of disconnecting the engine at will, so that the car may be stopped in traffic or for other short periods without arresting the engine. It is a necessity in driving as the gear changing can only be undertaken after de-clutching, and it allows the high rotative speed of the crank shaft to be gradually transmitted to the driving gear, so as to minimize the shock of coupling up.

The frictional surfaces of the clutch are normally in contact, and have to be separated when required by the depression or pushing of the clutch pedal, so that this pedal may be considered as having a negative action, an important difference between it and the brake and accelerator pedals.

*The Gears in Neutral and their Ratio.*—The male portion of the clutch is always in positive connection with one or both shafts in the gear box, so that when the engine is running idly, and the car is stationary, movement is taking place in the gear box, a fact which cannot be too strongly impressed on the novice. The car under these conditions has the gear lever in the neutral notch, and must on no account be moved until the clutch pedal has been depressed and separated the two portions of the clutch. In some cars this source of danger has been fully recognized, and by means of ingenious mechanism it is impossible to move the gear lever without first de-clutching. Various ratios of gearing are provided so that the engine will be able to maintain the same tractive effort under all conditions. If it is going uphill a small wheel on the primary shaft of the gear box intermeshing with a comparatively much larger one on the secondary shaft will allow the same amount of twisting force or torque to be transmitted to the road wheels as when there is less difference in the sizes of the gear wheels of the two gear shafts and the car is travelling on the level. If the gear ratio is not altered, and the car encounters an incline, the engine is called upon to do an extra amount of work, and therefore slows down, as well as the car, unless other means are brought to its aid, such as altering the mixture entering the carburettor, or advancing the point of ignition.

*Transmission Summarized.*—One of the shafts of the gear box then transmits the power by means of bevel gear to a cross-shaft

which carries the differential gear in the centre and chain sprockets at each end, if it is a chain-driven car, while if it is a cardan shaft-driven car, which is more likely in the light of present practice, having a live axle, the gear box shaft will convey its power through universal couplings to a cardan or propeller shaft which is in direct communication with the differential gear, through which is driven the road wheels attached to the live axle. In a chain-driven car the back axle is a fixture, and the wheels rotate on the axle arms as in a horse-drawn carriage. Such is a brief outline of the transmission of the power from the tail end of the crank shaft to the road wheels. The various parts will now be studied in more detail.

*The Single-Cylinder Flywheel.*—In a single-cylinder engine the lower end of the connecting rod is connected by the crank-pin between the two halves of a double flywheel, weighted so as to balance the impulses. The whole arrangement is contained within the crank case, and necessitates a separate outside member for the sliding portion of the clutch to engage with.

Clutches are of three patterns, (*a*) the cone with either the smaller or larger diameter towards the flywheel, (*b*) the disc or plate with plain or groove contact, and (*c*) the expanding, the order given being according to their degree of popularity.

*The Ordinary Cone Clutch.*—With the cone clutch of the ordinary type, that is, the smaller diameter engaging first with the flywheel, the latter is provided with a corresponding cone-shaped recess within its rim, so that the two portions engage with a loose fit, allowing for a thickness of leather with which the sliding portion is encircled. The flywheel is bolted to the tail end of the crank shaft by a collar, which may be let into a corresponding recess on the engine side of the flywheel.

The sliding leather-faced cone is bolted to a hollow shaft, which is free to slide on an inner shaft, having a front bearing on the boss of the flywheel immediately behind the tail end of the crank shaft, and the bolts which hold the collar just mentioned pass through a similar flange on the other side of the flywheel, holding all securely together. The other end of this clutch-shaft has, of course, a bearing in the front end of the gear box, often through one or a pair of universal couplings, especially if the gear box be a separate

unit. The hollow shaft, or sleeve, to which the male portion is bolted, although free to slide on the clutch shaft, is compelled to turn with it either by the bearing surfaces being squared or else castellated by means of outstanding feathers or ribs. The clutch is kept up to its work by a strong spiral spring encircling the clutch-shaft, having a bearing on two flanges, one at the back end of the clutch shaft, and the other at the end of the hollow sliding shaft. This shaft also has a grooved collar on it, into which a fork in connection with the clutch pedal can be moved. When the driver places his foot on the pedal the grooved collar is pushed against the spring, so that the clutch is disengaged. In designing this important part of the mechanism the main object is to provide a gradual and smooth contact. The leather may be provided with small spiral or other springs under its surface for that purpose, so that the centre of the leather tends to engage first, and the angle of engagement is also a determining factor, which in practice works out at about twelve degrees. The leather is attached to the flywheel with copper rivets, which have to be recessed $\frac{1}{8}$ in. below the surface, and in the wear which results these rivet heads have to be watched to see that they do not scratch the female portion of the clutch, a matter which has had something to do with the preference shown in some quarters for metal to metal clutches. The clutch leather may also be fitted in segments, making renewal a simpler matter. In the type of clutch described, the pressure of the spring when the clutch is in is continually pushing the ends of the shaft against its end bearings. To resist the greater part of this strain, a ball thrust bearing is provided, which has the effect of pulling against the tail end of the crank shaft, and so counteracting some of the opposing forces. The ball race nearest to the crank shaft is fastened securely to the clutch shaft, while the other race is attached to a housing fastened to the crank shaft.

This thrust, however, may be avoided by mounting the clutch on the extension of the crank shaft, which has a collar and nut provided for retaining the spring over which the sliding sleeve is encircled.

*The Reversed Cone Clutch.*—Another method of avoiding end thrust is to use the second type of clutch mentioned under (*a*), which has the larger diameter of the cone towards the flywheel,

also known as the reversed, inverted, or internal cone clutch. The cone may fit into the hollow of the flywheel itself, or into a casting specially bolted on for the purpose. The engaging spring, having to act in the opposite direction to the type already described, is between the flywheel and cone, and the fork from the pedal works in a grooved collar outside. This makes a more compact arrangement, but has the disadvantage that the spring is difficult to get at, while the flywheel has to be made in two pieces.

*The Multiple-Disc Clutch.*—With the multiple-disc clutch a number of plates are spaced equally apart, and attached to a case fitted to the flywheel. Between these plates another set are arranged, fixed inside a drum on the clutch shaft, so that when the pedal is released each pair of alternate plates engage and transmit the drive. The plates may be flat or grooved; in the latter case, these grooves or notches forming a series of small cone clutches. In the Hele-Shaw clutch the outer driving plates are of phosphor bronze, and the inner driven ones of steel. A sleeve slides on the clutch shaft in the usual way, and is provided with a shaped disc which, under the pressure of the ordinary type of spiral spring, presses against the end of the series of plates, so causing each pair to engage. The thrust is provided for because the outer collar bearing of the spring is directly attached to the flywheel. The plates work in a bath of oil, and in order that there shall be no sticking the driving plates are fitted with small laminated springs, which are in compression when the clutch is engaged. To ensure that the rotating clutch shall be quickly and easily arrested the actuator which is fastened to the clutch sleeve, and is worked by the pedal in its backward and disengaging motion, retreats on to a coned part immediately at the rear, so that a powerful brake is provided.

*The Single-Plate Type.*—The single-plate clutch is a simpler metal-to-metal type. The flywheel has a flat surface, against which the metal disc, free to slide on a squared shaft, is normally in contact. The metal disc is actuated by another plate immediately behind it, controlled by a spiral spring under control of the usual pedal, so that, when the car is running, three more or less disc surfaces are in contact—the flywheel, central metal disc, and the actuating disc. Slightly more complicated, yet more compact, is

the De Dion type, in which the metal disc is within a metal box bolted to the crank shaft extension. Within this case, on the gear-box side, is bolted a metal ring, which is in contact with one side of the disc, while on the other side is another disc, but free to slide slightly, and controlled by a series of small spiral springs arranged around its circumference. The pressure of these springs, as in other types of clutches, keeps the central disc in engagement, and their pressure can be removed by a series of suitable levers connected to the pedal in the usual manner. The multiple disc, and the single-plate clutch first described, run in a bath of oil, but the variety just described needs no lubrication of the engaging surfaces.

*The Expanding Variety.*—The expanding clutch is so constructed that, as it spins, it increases in diameter until it finally comes in contact with the inner surface of the flywheel. The action is centrifugal, and, as the clutch is capable of enlargement, it has to be in several portions, and, as the degree of centrifugal action depends on the weight at the rim, the clutch has to be made heavier here, although in the cone type an aluminium rim is often attached to a cast-iron centre, so that its spinning may be arrested with the least delay. The faster a car is going fitted with an expanding clutch, the tighter it holds, so that a strong and well-designed pedal arrangement is required for its ready disengagement.

*The Attachment of the Gear-Box.*—The gear-box casting is attached to the frame by suitable lugs fastened above or below to cross members or to a special longitudinal under frame. The gear-box arms are seldom attached direct to the sides of the main frame, the length of arm necessary being considered a source of weakness.

The gear-box should be as light and compact as possible, and the best patterns are of malleable cast iron with an aluminium lid, which is easily removable. Webs are cast on, so as to strengthen the box at the shaft bearings and to enable the box to have thin walls.

The principles adopted in transmitting the various ratios of speed are broadly of two kinds, (*a*) the shaft-to-shaft drive throughout, and (*b*) a similar drive on the low speeds with a direct drive on generally the top speed, during which the crank shaft is in direct communication with the propeller shaft, and turns at the same rate.

With the former type, the gear-box has suitable bearings for

two shafts, generally side by side, but they may be one above the other, one of which—the primary shaft—is in line with the clutch shaft, and the other with the bevel drive on the sprocket shaft, or the propeller shaft of a chainless car. When the car is at rest and the engine running, the primary shaft revolves idly.

*The Working of the Gear Lever.*—The changing of the gear lever from the neutral to the first speed position slightly revolves the cross shaft to which it is attached, which in turn actuates a selector lever, which, according to the position of the gear lever, engages with a slot in a certain selector bar. To this is fastened the proper fork which engages with a grooved collar, which pushes the proper wheel mounted on a sleeve (like a clutch) on the primary shaft into mesh with the right one on the secondary, counter, or lay shaft, the primary shaft having been slowed down by removal of the clutch.

The second speed is similarly worked through a different selector bar and fork, and probably a third speed also, while the reverse, which, by the way, is legally necessary, is arranged by inserting a third small pinion on a separate shaft, or shifting a pinion on the primary shaft into mesh with two others already engaged. As one of the outside wheels does the driving, the other end one will be revolving in the same direction or in the reverse way to which it usually runs when the forward gears are in operation.

*The Direction of Gear Wheel Revolution.*—This brings to notice the interesting point that the clutch shaft in front of the gear box, and the propeller shaft behind it, are, when the car is travelling forwards, revolving in opposite directions, the direction of movement being again reversed in the final bevel drive to the road wheels. Two or any even number of gear wheels intermeshing drive the outside ones in opposite ways, any odd number result in the same direction of movement of the outer ones. Also bevel wheels intermeshing on either side of another bevel wheel revolve in opposite directions. Two wheels joined by a chain or belt revolve in the same direction, or if the belt be crossed in opposite directions.

*Constant Mesh Gears.*—The second type of gear box has two shafts as before, but two of the gear wheels (one on each shaft) are always in mesh. The primary shaft is provided with a sliding sleeve as before, on which the gear wheels for producing the gear

ratios with those fixed on the secondary shaft are to be found. When the gears are selective through a gate change, as with most modern cars, each one or a pair of gear wheels is on a short sleeve of its own, but usually on the same solid shaft, so that one speed may be gained by shifting to the right, and another by shifting to the left without having to pass through any other gear ratio. With this type of gear box the low speeds, it will be seen, are obtained by the motion being transmitted first to the secondary shaft by the constant-mesh pinions, and then back again to the primary shaft when the proper gear wheels are in mesh.

*The Direct Drive.*—The direct drive is obtained by a dog or positive clutch (as distinct from a friction clutch) engaging, one part of which is incorporated with one of the constant mesh pinions, and the other generally on the side of the next lowest gear wheel.

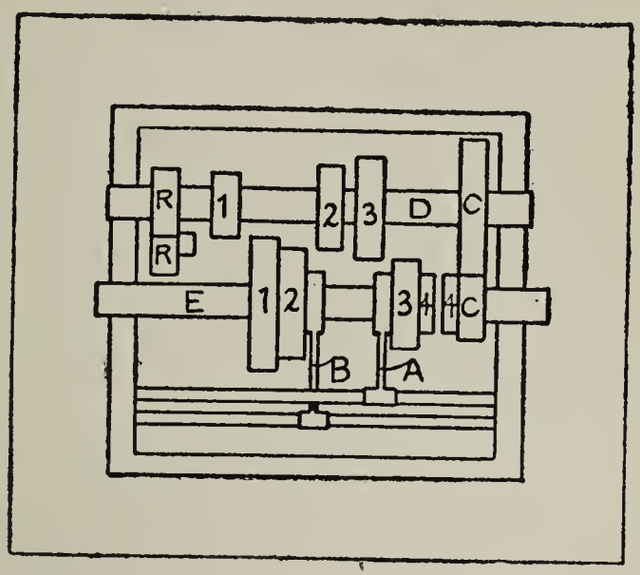


FIG. 38.—Four speed (selective) gear box. The numbering of the pinion wheels corresponds on each shaft, No. 1 engaging with No. 1 to give the first speed, and so on. No. 4 engages endways to give the direct drive. A, shifting mechanism for third and fourth speeds; B, ditto for first, second, and reverse; C, constant-mesh gear wheels; D, lay shaft on which the pinions are only free to turn with the shaft; E, main shaft connected to clutch shaft, and beyond to the propeller shaft; R, reverse pinion wheels, which are always revolving.

A plan now gaining favour is for the third speed wheel to slide into an internally toothed extension of the constant mesh gear. The power lost in transmission in the gear box is often as low as 10 per cent. on a car with well-cut and shaped gear wheels, carefully fitted and made of the right steel. On the other hand, the doubly indirect low speeds often entail the loss of quite 20 per cent., so that unless the direct speed is made use of considerably, its existence, seeing the lessened capabilities of the low speeds, is hardly justified.

If the constant-mesh pinions are at the back end of the gear box instead of the usual front position it can easily be arranged for the secondary shaft to run idle when the low speeds are not required. The sliding sleeve when it has attached to it all the

speed gears is known as the run or straight-through type, in which it is necessary to go through each speed when changing from the first to fourth, and *vice versâ*.

The primary shaft, on which the sleeve is fitted, is finished either square or with feathers or ribs as with a clutch, while the end of this shaft is shouldered down (spigotted) so as to give a bearing on which one of the constant mesh pinions may revolve, as it is necessary that it should have motion independently, since the sliding sleeve mounted on the same shaft has to transmit various speeds.

With the shaft to shaft drive throughout, the smaller wheels of each gear ratio will be on the sleeve of the primary shaft, but with the type giving direct drive on the top speed the arrangement will be reversed, as the drive being first transmitted to the secondary shaft by the constant mesh pinions, the larger wheels will be on the sleeve.

*Unit Construction.*—When the unit type of construction is used a series of attached castings may incorporate engine, flywheel, clutch and gear box. This means that the various parts so encased must be in line. On the other hand, the use of universal joints both in front and behind the gear box gives the drive a great amount of flexibility, and also does not demand a great deal of precision in assembling these parts on the chassis; also any great twisting strain on the chassis will not put it out of running.

*Gear Box Design.*—The modern gear box can usually be inspected from the top, the rest of the box being solid. If it is split at the bearing centre lubricant is liable to escape, and in some chain driven cars, where the gear box is well back on the chassis so as to keep the chains short, the bottom half of the box may come away, as inspection, with regard to the position of the body, is presumed to be difficult from the top. Lubrication is necessarily more effective and cleanly when only a light lid is removable, and if the shafts are side by side, rather than above one another, the lubrication of all teeth and bearings is more positive.

*Gear Wheels.*—The gear wheels themselves are seldom turned in the solid on the shaft, as renewals become very expensive. They are now either ring-bolted, or threaded on and keyed with distance pieces between. The teeth are cut in specially toughened

steel with great care to ensure accuracy, and the edges are bevelled so as to aid in the end engagement of the teeth.

The mechanism which enters the gear box to shift the gears should be designed so as to allow as little grit and dust as possible to enter, and for this reason most makes of cars have the selector rods and levers enclosed in the gear box, while the gate in which the gear lever works is sometimes encased also. The simplest method of changing, so far as mechanism is concerned, is of course the run-through type, and a small lever may be arranged conveniently under the steering wheel on the column.

*The Differential Gear.*—In the normal pattern of petrol chassis, the power is leaving the gear box by means of a shaft which is revolving at right angles to the hind axle, therefore it must be coupled to a bevel or worm drive, so that it may be utilized to drive the hind wheels. So long as the car travels in a straight line, over a level road of exactly the same character all over its surface, the friction between the hind tyres (presuming the wheels to be the same size, with same texture and so on of tyre) and the road will be the same. This, however, as might be supposed, is a practical impossibility even for a minute or two, bearing in mind the several circumstances which must prevail. If the back axle were positively geared to the transmission from the gear box, the result would be that in turning a corner no allowance could be made for the extra distance to be travelled by the outer wheel, consequently, even under favourable conditions, there would be plenty of skidding, as well as strain on the driving mechanism.

To obviate this the differential, or balance gear, is used, the same principle as adopted on a tricycle, which allows the two hind wheels to revolve at different speeds.

In the first place, if it is a chain-driven car, the counter shaft on which the chain sprockets are mounted is divided in the centre, while if it is a gear-driven car, the hind axle is similarly treated. To the inner end of each half axle or shaft is keyed a bevel wheel with the bevel facing inwards. At right angles, and equally spaced, are two, or generally four, smaller bevel pinions mounted on short studs fixed into the differential casing, so that the whole set of bevel pinions is inside. Outside the case is a large bevel wheel, generally called the crown wheel, which is in gear with a smaller

wheel firmly attached to the tail end of the propeller shaft. When the propeller shaft turns it revolves the crown wheel, and consequently the whole differential box with it. If the friction at the road wheels is the same on each side, the whole of the internal pinions will revolve solidly, transmitting an equal speed to both halves of the axle. Should, however, the car be turning a corner, or be steered out of the straight line, or encounter an obstacle, the pinions on one side will revolve on their own studs, and a corresponding decreased speed takes place on the side where there is the more friction. This is because the axle is in two halves, and each half is free to move independently, like the two sides of a pair of scales. If more weight is placed in one pan, that pan will lag behind. In the motor car, the weight is represented by the friction between tyre and road, therefore the greater the friction, the more that half of the axle will lag behind. In turning a corner the bottom point of the inside wheel becomes for the time being a pivot, and sets up considerably more friction with the road by reason of its position than the outer one, which is describing a circle of greater radius.

In place of bevel wheels ordinary straight pinions or face gear may be used, but the principle is the same.

When there is a live axle, the whole of the moving parts are usually covered by a hollow casing, on the ends of which the hind springs are mounted, so that the weight of the car is borne independently of the transmission mechanism. The ends of the live axle are fastened by means of a dog clutch to the road wheels. With the crown wheel outside the differential case opportunity is taken to reduce the speed of the propeller shaft, as the pinion mounted on the end of the latter is considerably smaller, so that although there is a "direct" drive, the engine speed is not transmitted to the road wheels. The inner differential case is in two halves, so that it can be assembled with the half axles and pinions, likewise the outside case covering the crown wheel.

*The Back Axle.*—The tube carrying the live axle inside not only carries the springs on suitable flaps, but the bearings for the hind wheel brakes which are worked by the usual hand lever. A tie rod is usually present to strengthen the whole, while webs are cast on at the point where the strain is greatest, as with a gear box.

With a chain-driven car the axle is as simple as with a horse-drawn carriage, all the necessary complication being confined to the sprocket counter shaft. This "dead" axle may be a solid forging, tube, or of H or other section; it may also be cranked so that the body may be brought lower to the ground.

*Epicyclic Gears.*—Another type of change-speed gear consists of the planetary, crypto, or epicyclic gear, in which gear wheels are constantly in mesh, and convey power, when required, by means of band brakes. One of the names by which this system of gearing is known, it will be noticed, is the "planetary system." This is because a central sun wheel is intermeshed with one or more surrounding planet wheels. The sun wheel is keyed to the crank shaft, and the planetary wheels, although free to revolve on their own centres, cannot move independently away from one another, being held apart at equal distances by a star-shaped device. The sun and planet wheels revolve as a whole inside an internal gear wheel.

The principle of working will be first explained, and then the modifications adopted in the application. The central sun wheel is keyed to the crank shaft, so that it always revolves with it. The planetary wheels are centred on studs attached to a ring or star, which is mounted on a sleeve, so that it may move independently of the crank shaft. The outer ring, with its internal teeth, is similarly mounted. When the slow speed is engaged, a band brake is brought into operation, which holds the outer ring stationary. The sun wheel, in revolving, causes the planetary wheels to revolve on their own centres in the opposite direction, but, owing to the internal gear ring being fast, these wheels mount round it as a series in the same direction as the crank shaft, and at a reduced speed proportional to the number of teeth on the planetary wheels and the number on the internal gear ring.

For the high speed a clutch engages with a cone forming a part of the internal gear wheel, and, no band brake being in operation, the set of gearing revolves as a whole at the crank shaft speed, but the planetary wheels do not revolve on their own centres independently. For the reverse, another band brake is used, which holds the ring on which the series of planetary wheels are mounted. This has the effect of allowing them to revolve on their own centres,

but not round the sun wheel, consequently they transmit their motion to the internal gear wheel, moving its rim in the opposite direction to that of the sun wheel and crank shaft.

In practice, when there are two speeds, and a reverse, there are two sets of sun wheels and surrounding planetary and internal gear wheels. Between these two sets of wheels is mounted a sprocket or other wheel for transmitting the drive to the back axle. This sprocket is integral with a sleeve, on one end of which is mounted the ring or plate carrying the studs and planetary wheels for the low speed, and at the other end the internal gear for the reverse. Over this reverse internal gear wheel is carried another sleeve, mounted from the engine side, which carries the planetary reverse wheels, while over the ring carrying the low-speed planetary wheels runs a sleeve mounted from the back axle side, carrying the low-speed internal gear wheel. Over each of these outer sleeves runs a band brake, the last-mentioned being also provided with a cone, so that it may be revolved as well as arrested.

By applying the band brake on the sleeve which has an internal gear wheel on it, the crank shaft moves both sun wheels, all the planetary wheels in both sets, and incidentally the internal gear wheel provided for the reverse, but, of course, only idly.

For the high speed, the clutch moves the internal gear wheel, which has recently been held fast, and takes round bodily with it both sun wheels, all the planetary wheels, and the reverse internal gear. When the reverse is in operation, a band brake is applied to the sleeve outside the reverse internal gear wheel, which carries the reverse planetary wheels. This, therefore, prevents their rotation round the sun wheel, but allows them to revolve each independently on their own centres, driving the internal gear ring in the opposite direction, and the sprocket wheel with it.

The central sleeve, which carries the sprocket, the forward planetary wheels, and the reverse internal gear, are always revolving, whether the high, low speed, or the reverse is being used.

This system of change-speed gear is but little used, probably owing to its seeming complication, that is the large number of wheels necessary to effect only two speeds forward and a reverse; but, on the other hand, the actual gear changing is more easily done, and requires little experience, and, from the engineering point

of view, is a more satisfactory method, although, as practice goes to show, under ordinary care and with a fair amount of skill, the normal type of gear box wears well, except, perhaps, for the arduous service which omnibuses and cabs have to undergo.

The objection that only two speeds can be obtained has been removed, and in modern cars one may have three speeds forward and a reverse. The principle of working by means of the application and release of band brakes, and the use of planetary and sun wheels, is similar, but there are naturally differences as to detail.

The following should be read in conjunction with Fig. 39.

*The Adams Gear.*—A notable type is that used on the Adams car. The whole gearing is contained in an aluminium gear box, so that the mechanism is protected to the same degree as with the ordinary sliding type of gear box, a refinement which has not always been present with epicyclic change-speed gears. A sun wheel A is keyed to the shaft B, which is in direct communication with the female portion of an ordinary cone clutch. This sun wheel is then in constant mesh with two planetary wheels, C, C′, the duplication of these wheels, and in the type just described, only being done for the sake of balance. Each of the planetary wheels is keyed to a shaft running in a cage, similar to the inner case of a differential gear (in fact, the comparison is carried further, because a differential action takes place within this cage), and these shafts carry the necessary pinion wheels for the various speeds. The clutch shaft is spigotted into the propeller shaft as in a direct-drive gear box, and here is mounted a gear wheel E on a sleeve, constantly in mesh with another wheel F, positively connected to the same shaft as the planetary wheel C. There is no internal gear wheel with the Adams gear. Taking the second speed first, the main clutch transmits power to the sun wheel A, and then to the planetary wheels, one of which, C, is on the same shaft with the wheel F, which is intermeshed with the wheel E on the sleeve of the propeller shaft. The speed is reduced as between clutch shaft and propeller shaft owing to the number of teeth on the sun wheel A being less than those in the planetary wheel, C. While this speed is in operation the gear cage is held fast by the band brake, G. For the free engine motion the cage is released, with the result that the pinion F walks or mounts round E, which is the

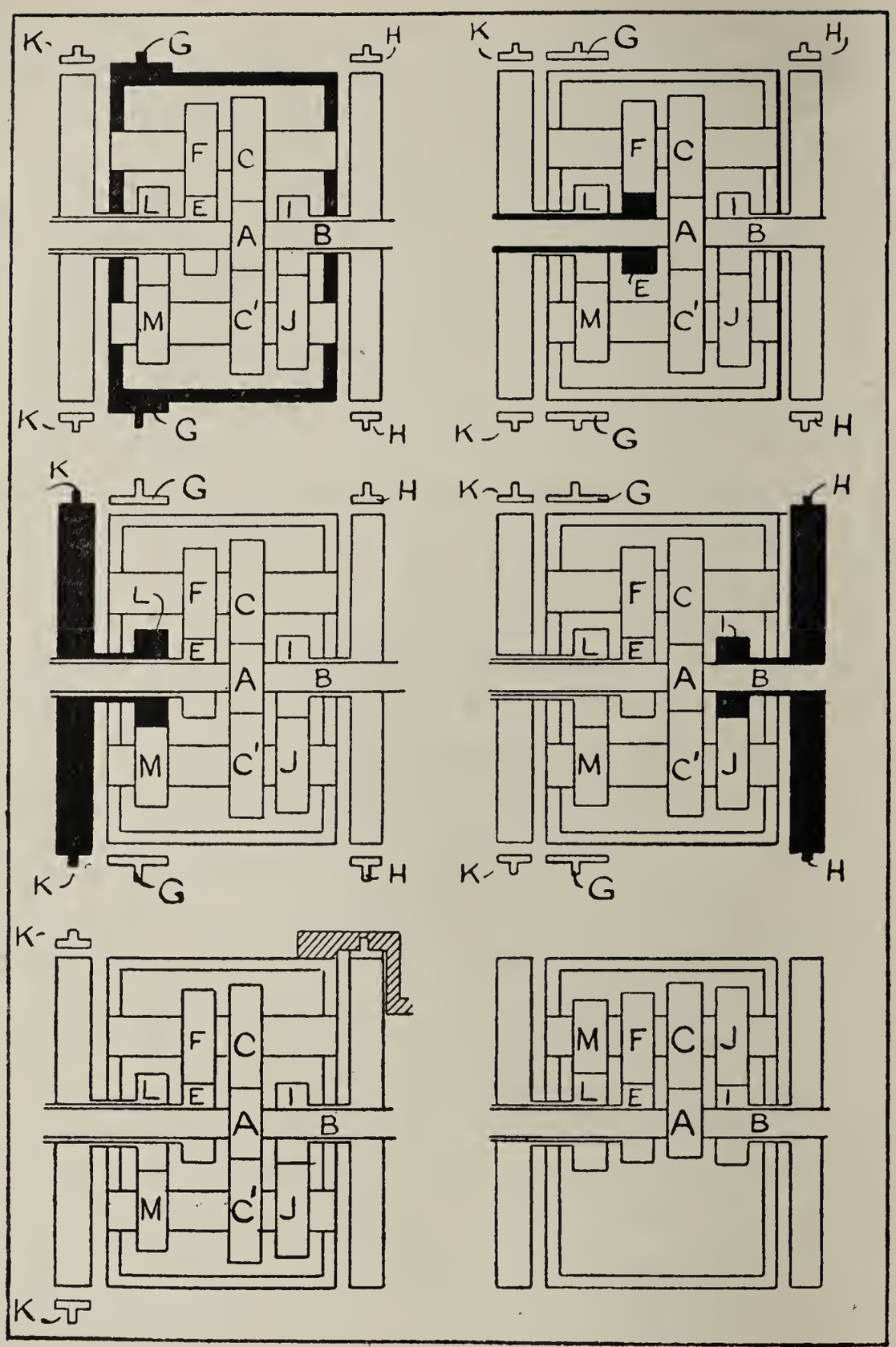


FIG. 39.—Diagram illustrating the Adams (Epicyclic) change-speed gear. The blackened portions are stationary in each case. 1, second speed; 2, first speed; 3, top speed; 4, free engine; 5, reverse; 6, how the gear wheels would be arranged if there was only one shaft; A, sun wheel; B, clutch shaft; C, C′, planetary wheels; E, pinion in connection with propeller shaft; F, pinion in mesh with E, and keyed to upper shaft; G, band brake acting on gear cage; H, band brake acting with reverse pinion I; I, reverse pinion; J, pinion in mesh with I, and keyed to lower shaft; K, band brake acting with pinion L; L, pinion in mesh with M keyed to lower shaft; M, pinion giving second speed with L. For further detail see pages 231, 233.

pinion in connection with the propeller shaft, and does not revolve it, since the gear reduction which takes place does not provide sufficient power to overcome the resistance between road wheels and road. For the reverse speed the band brake H, in connection with the gear wheel I, is provided. This wheel intermeshes with the wheel J on the lower shaft. This band brake H being applied, and the cage brake G taken off, the wheel J mounts round wheel I, taking the cage with it. This is because the wheel I has less teeth than wheel J, consequently, the differential action works the cage in the reverse direction to the clutch shaft. For the first speed a similar action takes place, but in the opposite direction. A brake drum K at the other end of the cage is in the solid with a gear wheel L intermeshing with a pinion M on the other end of the lower shaft. This wheel M has less teeth than wheel L, therefore the differential action is in the opposite direction.

For the direct drive the cage and reverse band brake are held fast together by a cone working against two scissor levers, so that the whole revolves as an extra flywheel at crank shaft speed.

A well-known instance of the use of an epicyclic gear box is the system adopted by the Lanchester Motor Co., Ltd. The Lotis car made by Sturmey Motors, Ltd., also has a gear box working on a similar principle.

*The Linley Gear Box.*—Another type which illustrates an up-to-date constant meshing type, but not an epicyclic pattern, is the Linley gear box. Here the wheels are provided with end-engaging dog clutches, the coupling up of which is done with great ingenuity by means of specially shaped cams and spring-controlled levers. The gear box contains a primary shaft, into which is spigotted a secondary shaft, both shafts being squared, where necessary, to take the sliding halves of the dog clutches, while the gear wheels on the primary and secondary shafts are free and fixed respectively.

A countershaft has keyed to it the remaining pinions for the various speeds, while a separate cam shaft is also present, by means of which the dog clutches are brought into play. The engagement of a gear does not take place when the gear lever is shifted into its proper position, but it is necessary to declutch or reduce the load on the gear already in mesh, before any change can be effected. The unique features of the gear box are the cam shaft and the cams

attached thereto, and the mechanism which they actuate. The cams have their faces specially shaped with regard to their profile, which is in the nature of a return curve, and it should be noted that the face, and not the edge of the cam, operates the mechanism with which it comes in contact.

Each face cam operates two swinging levers, which have roller terminals. These levers lie closely each side of each cam with the exception of the reverse cam, which has only one. Each swinging lever is fastened securely to a short shaft running at right angles to the cam shaft, on which (free to revolve) is a sleeve carrying a pair of forks, between which is carried, by means of a universally jointed collar, the moving portion of each dog clutch. The action of the profile of the cam is so arranged that, as the cam shaft revolves by means of the bevel gearing in connection with the gear lever, in one direction, it moves the swinging lever on one side only, the other lever being operated on the return journey. The collar, with its two forks which carry the dog clutch, is carried on a sleeve, which, it will be remembered, is free to revolve, so that, to ensure the swinging levers moving the dog clutch on the squared shaft, the inside fork is provided with a short striking lever, which comes in contact with the swinging lever when it is operated by the cam. These last-mentioned levers are controlled by special springs, so that, when the gear lever is shifted, the power so transmitted is conveyed and stored up in the springs until the particular dog clutch is disengaged by depressing the clutch pedal, or in any way whereby the load on the particular clutch is decreased. When the top speed is in operation there is a direct drive, and the lay shaft carrying the keyed gear wheels is at rest, owing to the fact that the pinions, as mentioned before, are free to revolve on the other gear shafts. In changing from a high gear to a low gear it is only necessary to shift the gear lever and partially close the throttle. This type of gear box has been eminently successful as part of the transmission system of a well-known make of commercial vehicle, so that its practicability has already been proved, and its adaptation to the private car is for the greater part the designing of a lighter pattern furnished with a few refinements, and greater gear ratios, which has already been done.

# CHAPTER XXI

## *LUBRICATION*

An important consideration, from the user's point of view, is the maintenance of the lubrication of the various bearings in the car. Although many systems, to a great extent, work without attention for a considerable time, yet the lubrication as a whole demands more supervision than, say, the ignition, or the cooling water circulation. Of primary interest is the means adopted to effect the lubrication of the engine and its parts.

*The Gravity-feed System.*—The simplest method, the gravity-feed, is to employ an oil tank mounted as high as possible, having attached to it several separate leads (usually of copper piping) which run down to the part requiring lubrication. A convenient position is the engine side of the dashboard, where it is slightly warmed. If the tank can be mounted centrally over the engine, undue curvature of the piping is largely avoided, but this, in some cases, may interfere with accessibility to the valves and cylinders. With a system such as this, the pressure is, of course, according to the head of oil in the tank. In order to satisfy the driver that the oil circulation is in working order, it is arranged that a portion of it shall be diverted to the dashboard through a sight feed lubricator or some variety of tell-tale device, such as a gauge, or pointer, working according to the flow of oil.

The sight feed lubricator, which is seldom seen now on a new car, consists of a horizontal trough having a number of pipes leading from it, which should not be branched, so that interdependence is avoided. Each outlet is provided with a needle valve, somewhat after the style of the pattern used on a carburettor, and it is adjusted by a milled head and lock nut on the top, within reach of the driver's hand. If this dash lubricator is below the tank, the liquid

can run into it without any mechanical assistance. The use of the adjustable valve is to regulate the number of drops per minute passing to each bearing, as one, say, the main bearing of the crank shaft immediately behind the flywheel, may require fifty drops per minute, while a minor one perhaps only five; also adjustment will depend on temperature, as oil will flow more quickly in warm than in cold weather. Usually the tank is heated slightly in some way, either by the cooling water or exhaust piping passing through it, or simply by its location under the bonnet.

*Splash Lubrication.*—Most cars are now fitted with a lubricating arrangement which includes a splash or spray system arranged in the crank case of the engine. This consists of a pool of oil, into which the dipper attached to the big end of the connecting rod plunges at each revolution, thereby throwing or splashing a spray of oil, not only over the crank shaft, crank pin, and cam shaft bearings, but right up to the gudgeon pin inside the piston, from whence it runs down the walls of the piston, and forms in drops on the lip of the piston, where it is caught up and lubricates the outer surface of the piston, and consequently the cylinder walls. The splash system requires a constant level to be kept in the crank chamber, as the big ends of the connecting rods should dip about $\frac{1}{4}$ in. into the pool of oil. As the lubricant becomes spent further oil may be introduced into the crank chamber by means of a hand pump provided with a two-way cock, which at the upstroke draws oil from the tank and at the downstroke (the tap being turned so as to close the way to the tank and open that to the engine) forces it into the crank chamber.

Another method is to utilize the pressure of the exhaust gas, as with the petrol supply, and consequently a hand pump is necessary to create the initial pressure.

Splash lubrication influences to a great extent the design of the crank chamber. In order to keep the oil at the proper height, especially when the car is not on the level, the crank chamber is divided by vertical partitions, so that the forward cylinder is not starved when going uphill, while the one at the back end is being over-lubricated. The dippers, however, will usually plunge into small troughs rather than into the main supply, into which the troughs overflow. Another refinement consists in dividing the crank case

into two compartments horizontally, the lower one merely forming an oil reservoir. This lower division is so constructed that it receives the overflow of the upper part or crank case proper, from whence it is pumped up again.

*The Forced-feed Method.*—The forced-feed method is adopted on many engines, but seldom exclusively. In this system the oil is pumped through the crank shaft and pins through a special oilway which is drilled through these parts. Sometimes the connecting rod itself is drilled to convey lubricant to the gudgeon pin, but usually it is splashed up as already described, or a small copper pipe is attached, or it may depend on the oil thrown off the big ends and crank webs which has emerged from the bearings.

The crank shaft bearings, especially the one by the flywheel, are, owing to the heavy work they have to perform, usually supplied direct with oil under pressure, while the connecting rod and other bearings may simply depend on the splash method. In this instance the oil pump delivers lubricant through piping direct to these parts, the pump being driven by means of a vertical shaft provided with a bevel wheel intermeshing with another on the cam shaft. A simpler device, and considered by some just as effective, is to divert some of the spray set up by the oil splash into funnel-shaped channels, in which the spray collects and runs into the proper lubricating holes.

On the other hand, some makers have oil leads communicating direct, not only to the main bearings, but to those usually lubricated by splash only. With the splash system, as ordinarily fitted, there is a tendency for less oil to be splashed up as the speed of the engine increases, because the troughs do not refill fast enough. In other instances the troughs may be interconnected with the throttle so that, as the engine moves faster, the troughs are raised, and present a deeper well to the connecting rod dippers.

*Straining the Oil.*—When oil has done its work it becomes carbonized and in time will be impregnated with these carbon particles and fine metallic dust from the bearings, and other foreign matter, so that if it is to be used again it must pass through an efficient strainer, such as a system of different-gauge wire meshes, which must be easily removable to allow of cleaning at intervals. Clean oil is necessary, not only that it shall carry on its function of

reducing friction to a minimum, but also that it may flow freely in the small pipes, and other oilways. For the same reason the pump itself should be easily demountable.

*Replenishment and Over Lubrication.*—After a considerable period of running, according to the newness of the car, its horse-power, and the work done, the whole of the oil is drained off. When inserting the fresh supply some means should be provided so that the proper level is known, but in many cars, excellent in other respects, that is simply ascertained by reason of the oil overflowing. A large pipe connected to the crank chamber and whose top tallies with the right level, has been suggested as a suitable means of ascertaining the right level, and if such a pipe were placed near the front wing it would be readily accessible. A float working in a side chamber, as with some carburettors, has been adopted and has proved a very useful fitting to those who look for cleanliness in car operation.

Over-lubrication has to be specially guarded against in the cylinder walls, because by so doing oil may be forced into the combustion chamber, and cause a smoking and unpleasant exhaust. An excellent plan is to provide the piston with an additional ring called a scraper, or to drill a number of holes through the body of the lower portion or skirt of the piston, so that the oil may pass through to the outside. Leading authorities seem agreed on the point that it is unnecessary to lead oil direct to the cylinder wall, greater ingenuity being required to keep an excess away from these parts.

Oil pumps follow the main principles of others already described. An effective pump giving a high pressure of oil allows of the surface so lubricated to be somewhat smaller and to wear longer than where less pressure is present; also the oil leads are automatically kept free; but on the other hand it demands that the bearings shall be kept properly adjusted, and should the pump fail the system is at once rendered useless. However, as with other parts of the car's economy, the progress in motor engineering has brought the reliability of the lubrication system up to a high pitch, and the use of a forced-fed lubrication is partly or wholly the system used in the greater majority of cars to-day.

Apart from the fact that oil is led to the various engine bearings in several ways, there is also the question of whether it shall be used again or the further lubrication depend on a fresh supply.

Many declare that oil once used loses its lubricating power, but the successful running of cars fitted with circulating systems hardly proves this assertion. The defenders of the non-circulating systems point out that the foreign matter present in the used oil finds its way to the bearing, and increases wear and tear, also the straining systems used to clarify the oil each time it passes to the crank case are seldom effective.

The lubrication of the gear box may be effected by means of a special oil-lead from the same tank as that supplying the engine, but more usually thick grease is employed which half covers the gears, and helps them to run silently. All the mechanism which operates the gear change, and is outside the gear box, will require lubrication, such as the quadrant and the trigger of the levers.

Plate clutches of the multiple disc type run in a bath of specially thin oil, and the clutch striking gear, whatever its type, requires periodical attention. Lubrication is necessary at all points where movement, however slight, takes place, and the owner should at once familiarize himself with the lubrication system of his car, and many admirable charts are furnished for this purpose for hanging up in the garage.

*Lubricants.*—The oil used must be of the best quality, and suited to the particular bearing and its work. A good engine oil must be able to withstand the high temperature of the internal-combustion engine and be uniform in quality, so that its working powers may be safely pre-determined. One hears a great deal about body or viscosity of the oil, but this in itself is no indication of its lubricating value. Mineral oils obtained from similar sources to that of motor spirit are largely used, but the practice is recommended of compounding with fatty oils, as it has been proved in practice that the mixture so obtained produces less wear and tear and carbon deposit.

Some motorists have tried graphite mixed with oil and found it satisfactory, but the makers do not claim that this substance is suitable for gravity-fed lubrication systems. More extended trial of this substance would no doubt help to establish the position of this lubricant.

The parts which are lubricated with grease, such as the spring bolts, steering joints, and other small parts, are provided with a

grease cup. The cap of each of these can be unscrewed and filled with grease, and then brought into action by a turn of the milled head. A turn once in seventy-five miles is usually sufficient. The differential case may be filled with oil or grease according to its design; the hind live axle generally revolves in grease, and the front axle arms are provided with a similar means of lubrication.

Even the slight movement of the torque and radius rods should not be forgotten, while some joints, such as the steering knuckles and universal joints of the cardan shaft, are enveloped in a leather boot which is filled with grease.

The bearings of the magneto, commutator, and speedometer, being mechanism of special delicacy, require oil more of the character of sewing machine oil, that is of a vegetable nature, and as free as possible from a tendency to gum up and harden. Such a lubricant is very suitable for ball and roller bearings.

# CHAPTER XXII

## *BRAKES*

A ROAD vehicle which is capable of proceeding at a high rate of speed must be provided with efficient brakes, so that its motion may be retarded in traffic, and on gradients, and arrested in all cases of emergency. Although the motor car habitually travels quicker than a horsed equipage, yet the speedier vehicle is under a greater degree of control, and can be brought to a state of rest in less time and space; from which it may be deduced that in this case mere speed, by itself, is not an element of danger.

The use of rubber tyres, and the amount of friction necessary, precludes having any device which seeks to stop the car by the application of a shaped block to the tyre, as with metal-shod wheels.

The brakes furnished may be classed under the headings of "service" and "emergency" brakes.

*The Service Brake.*—The service brake is that used under normal conditions of travel, in order to slow up the car in traffic, at cross-roads and other common events of the road, such brake being operated by a pedal on the brake drums of the rear wheels, or, as is more usual with British cars, on the transmission system by means of a drum supported at the rear of the gear box, and keyed to the propeller shaft. In some cases, the brake and clutch pedals are interconnected, so that one motion of the foot simultaneously applies the brake and cuts off the power from the engine.

*The Emergency Brake.*—The emergency brake is operated by a hand lever, found by the side of the change-speed lever, and works on the wheel brake drums, and seldom on the transmission system, an internal expanding device being the usual variety adopted. The means for producing friction may be either by a contracting or expanding device, and although both are largely used there is an

advantage in favour of the internal expanding shoes, since it makes a neater apparatus, and one which can be kept more easily free from mud and dust, and therefore more likely to give satisfaction with but a little attention. Sometimes there is a wide drum or drums concentric to one another; in a few instances they are side by side, each having an expanding device within them controlled respectively by a pedal and hand lever, but, as a rule, if both service and emergency brakes are attached to the driving wheels, the same drum has mounted on it both expanding and contracting shoes, and usually the service brake is the external one and the emergency brake the internal.

An interesting movement is now taking place in brake design, in which a pedal-operated brake works on the drums fastened to the steering wheels, and those which have been fitted take the place of a transmission brake, that is to say, when front wheel brakes are used, the other means of control is confined to the hind wheels.

The hand lever may either pull or push on, and the former method being the more convenient it is usually adopted.

*Brake Friction.*—The ideal brake is one which develops a maximum of friction, while the heat which must necessarily be set up is quickly carried away by surface radiation, or by the jacketing of the drum with oil or water, so that the surface in contact shall not burn or deteriorate quickly. Other desirable features looked for are easy control by the hand or foot, both sides of the brake working equally, means for adjustment, and general accessibility.

The brake drum is bolted to the swelled portion of the spokes of an artillery wheel or may be secured to the inner hub plate, which is more desirable, and is necessary when wire wheels are used. Generally speaking, friction is directly proportional to the perpendicular pressure between two surfaces (if they remain in the same condition), it is independent of the areas in contact, and does not depend on velocity, but these laws do not hold good when the pressure or velocity is beyond certain limits, neither are they true for rolling or axle friction.

In other parts of the car lubrication is carried out to reduce friction; here all grease and oil will be eliminated as far as possible, except what is required to prevent undue wear and tear. The degree of friction also depends on the nature of the materials used,

and special substances are available which hold well and last a considerable time.

*Pedals.*—Taking the service brake first, the pedal or foot lever should be within comfortable reach, and if different persons are likely to use the car, it should be adjustable as to its height, which may easily be effected by mounting it on a short arm drilled with two or three holes, while the pedal should not have to travel more than 4 to 5 ins. before it is fully at work. At the same time, the tread should be centred at the end of the pedal lever, so that by manipulating a nut the angle of the pedal may also be varied to suit the height and position of the seat. The brake pedal is situated on the right-hand side of the steering column (with the clutch pedal on the left), and varying types of levers and rods transfer pedal movement into the cross motion at the centre of the car, if a transmission brake is used, and in addition some compensating mechanism will be furnished, if wheel brakes are used, so that the pressure shall be alike on either side of the car. The brake pedal lever is centred to a cross shaft, which also carries the bearing of the clutch pedal.

*The Transmission Brake.*—The normal type of transmission brake is situated at the rear of the gear box, and a convenient centre for the brake shoes will be by means of a short shaft having a bearing on the bottom of the gear box, or each shoe may have its own centre on a separate stud; and usually the shoes work outside the drum. This is of pressed or cast steel, and from $\frac{5}{32}$ in. to $\frac{3}{16}$ in. thick, and accurately turned if a metal to metal brake. The drum is keyed to the propeller shaft, and being forward of the final gear reduction at the rear axle bevel drive, revolves faster than the wheel brake drums, so that any pressure exerted on it has a greater controlling effect. Cooling may be carried out by ribbing the shoe, if an external brake, or ribbing the drum if an internal one.

Some are of the opinion that this brake is open to the objection that an extra strain is thrown upon the transmission system, which necessitates it being specially strong. On the other hand, with reasonable care in driving, compensation is effected through the differential gear without further complication, and the whole mechanism is more out of the way of dust and dirt than with side brakes. Should, however, the gear box be situated by the rear axle

casing, as with the Sheffield Simplex and Sizaire cars, the brakes are confined to the road wheels, as the extra weight and complication on the back axle would be undesirable. To the brake pedal lever is attached the connecting rod, which being used only to exert a pulling action may be light in substance, while according to the style of brake, so the operating crank levers and its mounting will vary. It is considered the best practice to attach the fulcrum to the adjacent subsidiary member of the frame, but if this is not done, the fixing to the gear box must be strongly carried out with a view to maintaining the correct working of the brake, without straining the gear box. Sometimes the connecting rod will impart a transverse movement through a vertical pivot, or, may be, the pull will transmit a slight turning movement so that hook clutch draws the two shoes towards one another. In one instance the mechanism immediately operating the shoes is through bevel gear.

The pivoting of the brake shoes may be either at the top, bottom, or side, while the drum itself may be cast with spokes. A wide braking surface, although not increasing the power, enhances the wearing capacity, and it is usual to insert one of the main shaft universal joints within the drum. As the brake shoes wear they should be capable of simple adjustment by a fly nut, or by an ordinary nut and spanner. The brake is released by a helical spring anchored at one end to the drum.

The motion is imparted from one shoe to the other by a tension rod, which must be kept up to its work by the adjustment provided. Those who dislike the idea of a transmission brake being continually in use have the option of purchasing cars in which the usual practice is reversed; that is, the service brakes are foot-operated in the ordinary manner, but connected to the road wheel drums, and the emergency brake is controlled by a side lever working a type of brake as just described. The Daimler car is fitted up in this way, the transmission brake being a band, and not a double shoe brake.

The transmission brake has the simplest mechanism when it lies close to the pedal rolling bar, and on those cars which are assembled with the gear box bolted direct to the engine and clutch case as one unit, a fulcrum and lever can be made to act directly on the end of the rolling bar.

Apart from the question of design, there are differences of

opinion as to the material which is to be used. Theoretically, the best substances to use for the contacting surfaces are those which grip easily, that is, have a high coefficient of friction. It has been proved that mixtures of metal and cork, leather or fibre, on a dry metal surface, adhere better than if the non-metallic elements are used alone, and the results go to show that fibre makes the best braking substance in conjunction with a metal, and the presence of oil does not destroy the holding power of the brake as much as might be supposed, and it allows the apparatus to act more gently, for fierce working is not a feature to be sought, owing to the strains which would be set up, apart from the fact that locking of the wheels would take place, which is disastrous to the tyres, and a hindrance to the stopping of the car. A brake, as its name implies, should retard the car only, and is not intended to arrest it suddenly. The oil also preserves and cools, but should any leather lining become charred, the power of the brake is considerably reduced.

Brake linings consist of asbestos and brass wire interwoven, and this material has been found to work satisfactorily under the most arduous conditions and for the heaviest vehicles.

*The Brake Lever and its Connections.*—The side brakes are, as pointed out, usually of the internal expanding type. The brake lever is centred on a bracket bolted to the chassis side member, and is provided with a trigger by the side of the handle, which is in connection with a pawl which engages with the teeth of a brake rack below. The brake lever is usually the outer one ; in the Deasy car it is inside, while the ideal position is in the centre of the frame, although it means a left-hand control, yet it would make a simpler job of the equal application of the side brakes.

The pulling or pushing of the lever into engagement allows the pawl to run over the teeth in the rack, and is held there until released by pulling the trigger towards the handle. The range of the brake lever varies from 7 ins. to 12 ins., and, so far, few brake racks are enclosed, but it is a detail which improves the appearance and keeps out the dirt. The rolling bar, to which the lever is fastened, has also attached to it the cranks, from which proceed the connecting or side rods to the rear of the frame. It is claimed that rods with well-designed joints are preferable to cables, as these have to take up very quick curves in passing over the guide pulleys,

yet at the same time this flexible system is more easily compensated. There are several moving parts, even in the simplest pattern of brake, and although the work done by the several joints is very little in comparison to that of the engine parts, yet each bearing should be lubricated by a small grease cup, which will only require attention, say, once a month, and should have hardened steel pins and bushes which may be easily renewed. Worn brakework is the cause of much rattling.

In choosing a car, the position of the various parts of the brake mechanism should be noted, to see that a fair amount of clearance is allowed from the other parts of the car, so that there is no likelihood of any chattering being set up in this way, which will often happen, say, at the rear axle casing after prolonged wear.

*The Internal Expanding Wheel Brake.*—This consists of a pair of metal shoes, sometimes of pressed steel or manganese bronze, to which are riveted cast-iron plates, which, when worn, may be renewed, or, if of cast iron entirely, the whole shoe is replaced. The two shoes are hinged to a special bracket on the axle sleeves, and a cam, more or less of lozenge shape, is mounted between the free ends, which, when turned by the action of the fulcrum, forces the two shoe ends further apart, so pressing the cast iron surfaces against the inner face of the brake drum. The shoes are normally kept out of contact with the drum by means of the usual helical spring, which may be duplicated and anchored across corresponding points of each shoe, or to the body of the drum. The Wolseley car has a flat horseshoe-shaped spring, which gives a powerful return, and is not affected in its action by mud and little by rust.

Adjustment is carried out by shortening or lengthening the connecting rods, a turnbuckle being provided for this purpose, care being taken to adjust each side alike. These adjustments are made easier if self-locking thumbscrews are provided at the back ends of the pull rods.

The shoes must be free from the drums when not in use, otherwise they will drag and set up heat and noise. In place of two shoes, a single flexible band is centred on the drum as before, which is expanded by a toggle joint, which straightens up when the hand lever is applied. These brakes may also be adjusted by taking up the side rods, and by taking up part of the toggle joint, but it

is necessary to remove the wheel before this can be done. With the hinged shoe type of brake, the two contacting surfaces when out of engagement form practically concentric circles, so that when the brake is brought into play the shoe cannot possibly touch all round the drum to the same extent. The pressure exerted is greatest where the shoe first touches, which is, of course, near the hinge and away from the cam.

*Compensating Devices.*—As with the pedal-operated brake, the power is applied at one side of the car, and as the wheel brakes are on both sides, some compensating arrangement is wanted, so that both brakes shall be applied with equal force. The Rolls-Royce car has a small differential gear fitted so that both service and emergency brakes are equipped alike. A more ordinary way is to have an evener or balance bar, to the centre of which is brought the brake rod or cable, while the ends work in slides attached to the insides of the web of the frame, and have fastened to them the connection to the fulcrums on each side. The wire cable compensates simply by one end being attached to each brake, the cable running through a hollow shaft to which the brake lever is fastened, so that when this is operated the cable can slide through and adjust itself to the pressure applied at either end of the cable.

A shorter balance bar may also be used; while with the Weight hydraulic brake, a pedal actuates a small plunger pump, the pressure being transmitted to all four wheels through flexible pipes containing oil.

*Double Action.*—A brake should be double acting, that is, control the car equally well in both directions, the backward braking being of vital importance when ascending hills. This is provided for when the band is attached to a fixed centre half-way round the circumference of the drum, that is, to be double acting the band must have an independent portion for each direction, and all shoe brakes are now fitted in this way, either from a common or separate centres.

The proper use of the brakes forms an important feature of good driving. They should be used as little as possible, and it should be borne in mind that the throttle lever is always available for slowing down the car with the least possible wear and tear, while the disengagement of the clutch also assists in this way. Keeping the clutch *in* will help to control the car should there be

any danger of it running backwards on a hill, and in the absence of the old-fashioned sprag some cars are fitted with a pawl and rachet wheel at the back of the gear box, which cannot be "jumped over," as with a sprag.

*Front Wheel Brakes.*—Front wheel brakes came first into prominence at the 1909 Olympia show, and have been fitted to horse carriages as long back as 1896. These brakes, so far, have been fitted to such cars as the Adams, Argyll, Arrol-Johnston, Crossley, Spyker, and Thames, and are pedal-operated service brakes. The chief advantage claimed for them is freedom from side slip, which is always probable with driving-wheel brakes, and should the wheels encounter a greasy surface they are free to move in any direction. Supposing the front wheels to be locked, whatever direction the car takes the freely revolving hind wheels must follow, but if the hind wheels are locked the tendency will be for them to reverse the direction of the car, and trail the steering wheels. Front-wheel brakes remove any objection which may be raised to the strain of a transmission brake; they are more accessible than the other types used, and by their forward position are naturally cooled. Special allowance has to be made, however, so that the steering is interfered with as little as possible; also compensation is required, allowance for spring action, and movement of the stub axles. The extra torsional stress which is thrown on the front axle and springs should be provided for by using a stiffer section, or adopting one of circular pattern, and radius rods should be attached so that there is a minimum of end compression on the spring plates. The brake shoes or band must work from the same centre, or one concentric to the axis of the steering pivot, and it is necessary to have the steering centre and the vertical axis of the wheel meeting as near as possible at the point of contact of the tyre with the road, so that the strain on the steering gear is low, and less likely to affect the braking mechanism attached to the front wheels.

When the wheels are so pivoted, they do not tend to roll round into a new position, and theoretically the steering should be unaffected, but as the road contact is not a point, some strain is sure to be present. This is often done on cars having no front-wheel brakes, where it is not essential but a refinement. It is done

by inclining the steering pivot centre to meet the centre line of the dished wheel, or by placing the pivot right inside the hub. The brake drum has to be rigidly attached to the stub axle, which entails radical alteration from the usual mounting of the wheel, in which the stub axle is hollow, and a short pin fastened to the hub revolves inside it.

Most of the brakes used are internal expanding. The Crossley has four shoes, each working on its own rock shaft; the Argyll brake has the operating shaft carried through a ball and socket joint on the frame; the Arrol-Johnston has the brake shoe expanded by gear segments; while Bowden wires simplify the mechanism of the Adams device.

As the front wheel brakes are much exposed, the enclosed expanding type would appear to be the most suitable. Detachable wheels can be fitted, if desired.

Brakes should be constructed with a fair margin of strength, as the safety of the passengers will depend on the effective control of the car under all emergencies; and as many cars travel far and wide, over strange roads, long hills are often encountered which will try the brakes to their utmost. When driving a strange car, it is a measure of precaution to examine the brakes.

# CHAPTER XXIII

## *THE STEERING GEAR*

*The Ackermann Axle.*—The steering of the car is directly under the control of the driver, and is effected by means of the two arms, hub spindles, or stub axles of the front axle bed being pivoted. This jointed axle, known as the Ackermann axle, was invented nearly one hundred years ago, but it has never been adopted to any extent, nevertheless the motor car manufacturer at once saw in it a means whereby increased stability over the central perch bolt system could be obtained, coupled with the advantage that it was eminently suited to the low and forward position of an accessible engine.

*The Steering Mechanism.*—The mechanism consists of a steering wheel, either of wood, wood and leather, or celluloid (which is cleaner but inflammable) covering a metal casting, consisting of a rim and spokes, which is centred on, and attached to, a steering pillar running in a casing, often brass or nickel-plated, attached to the dashboard. The internal pillar, continuing forwards and downward, terminates in a short worm, usually separate and afterwards attached, the threads of which engage with the teeth of a sector running on a short cross-shaft mounted in a steering box bolted to the side member of the frame. In place of a worm and sector, the former may engage with a nut, or a bevel and crown wheel may be adopted, or in place of a sector, a whole pinion may be used so that the few teeth which normally engage may be turned round as they wear, and a fresh set presented to the worm.

From the spindle, which receives motion from the sector, a short vertical lever is attached, whose lower end forms part of a ball and socket joint. The smaller part of the lever, just above the ball, passes into the split socket of the longitudinal steering rod by means of a slot, while the end motion and vibration is absorbed by

means of strong spiral springs abutting on the two halves of the socket. The longitudinal rod runs forward and is attached to the steering arm, which is secured to, or may form part of, the knuckle pin and stub axle on the same side. The steering arm continues forward and is fastened to the transverse connecting rod, which joins it to a similar front portion of steering arm on the near side, thereby ensuring that the two stub axles shall move simultaneously.

*The Design of the Ball Joint and Steering Arm.*—A well-designed ball joint should allow of plenty of wearing surface, and if lightly constructed some type of safety pin may be rendered necessary in order to prevent the ball from working through the slot above owing to excessive wear, but with occasional inspection and the maintenance of proper lubrication, such a state of affairs should be an impossibility. With regard to the steering arm, it is the practice of some makers to stamp this, together with the knuckle or pin and stub axle, all in one piece, afterwards bending them to the proper shape; but the all-in-one design seldom allows for sufficient strength in all the various parts, and is more expensive to renew. It is a better plan for the steering arm to be quite separate, provided with means for passing through and fitting well into a conical hole, and keyed to the steering knuckle and designed at the front and rear for attachment to the connecting and longitudinal rods respectively. The main or bed portion of the axle has jaws so as to embrace the two ends of the horizontal knuckle or pivot, and roller or ball bearings are provided in the upper half so that lubrication can be carried out with a minimum of attention. In place of a jaw, the axle pivot may be embraced by a coned cap, which is a somewhat stronger connection, and gives a maximum of bearing surface, although it means more weight and expense. The steering gear and its connections should be well designed and accurately fitted, otherwise much vibration and noise is set up, the former detracting from the comfort of the driver, being directly communicated to him through the wheel. Lubrication of some of the points is often carried out by leather boots filled with grease, but these need to be well fitted in order to do their work properly. Lubricators of the Stauffer type should be fitted whenever possible, and, as with the stub axle and its surrounding box, wear and tear is reduced to a minimum if the pins and sockets, worm and sector are case-

hardened, or some type of easily renewable bushing is inserted. Badly fitted steering gear, or a type difficult to adjust, means greater wear on the tyres owing to the unequal dragging effect when the wheel is operated.

*Wheel Lock.*—The Ackermann type of axle, seeing that only two short stub axles are moved, allows of greater stability of the fore-structure, apart from its lower centre of gravity, than the horse-carriage method, therefore greater speeds are permissible. A full lock or complete turning circle of the fore-carriage is impossible, but, on the other hand, the height of the frame from the ground is not dependent on the diameter of the front wheels, although, curiously enough, the average height of front wheel of a car is less than that of the normal brougham or landau front wheel, the size being dependent on other considerations as well.

The wheel lock is given as great a latitude as possible by narrowing in the frame in front of the dashboard, where the side travel takes place, while in some axles this may be assisted by throwing back slightly the centre of the knuckle from the centre line of the axle. The full range of the lock should be controlled by less than a complete revolution of the steering wheel. When the car is following a curved path, the longitudinal axes of the front wheels should both be at right angles to the radii of concentric circles, and not from centres of circles having equal radii. This common centre should be situated on a line produced from the centre line of the hind axle, so that the car, in turning, pivots from one centre only, diminishing, as much as possible, any unequal strain on the front tyres. The stub axles are set to this common centre by making the distance between the steering pivots so much less than the length of the connecting rod of the steering arms. This connecting rod may be placed either in front or behind the front axle bed. If outside, care must be taken to see that it does not interfere with the starting handle, or come too close to the spokes; and, if inside, in the way of the crank chamber and not inaccessible. In this position, however, it is out of the way of possible collision.

*Steering Wheels and Tillers.*—Wheel steering is universally adopted by motor car manufacturers, as only a slight movement of the wheel is required to give a comparatively large turning movement to the front wheels, and if a fair-sized wheel of some 16 ins. is

used, the comfort of driving is increased, owing to the extra leverage obtained, and therefore less effort required. This is not entirely dependent on the size of the wheel, but the design and excellence of fitting and lubrication of the several parts all contribute to the exertion required to steer the car in the desired path. Tiller steering, something after the bath-chair fashion, was largely adopted in earlier cars, and it had the advantage of allowing a free entrance to the driving seat; but now that more than one pattern of hinged steering wheel has been placed on the market, this superiority does not remain, but a free passage on either side of the car is also decided by the lever position, and steps have been taken by some makers to so place the gear and brake control that a more suitable position, from the owner's point of view, is obtained.

*Steering Column Angle.*—One difference between the car of yesterday and that of to-day is the angle of the steering column. The racing cars, of which so many were built during the days of the Gordon-Bennett and other famous road races, were largely fitted with columns having a decided rake, in contra distinction to the more upright type of the contemporary touring car. It was considered that such a pattern gave the driver more control over the direction of his car, and at the same time placed him in a more comfortable position, provided a suitably designed seat and padding were at his disposal. The raked column of to-day is largely the outcome of a desire to give the car a sporting appearance, while the lower seats which have become necessary have been found by many more comfortable for long journeys, although they may not conduce to sight-seeing.

*Adjustable Columns.*—A raked steering column generally means that five or six extra inches are demanded from the useful body space, although it would appear possible to incline the column, and still keep the same overall length from the dash to the back of the steering wheel for those who do not require the low seat. A refinement, adopted on some cars, is to hinge the column at the dashboard, so that varying angles may be given to suit different drivers and types of bodies. It should be possible to give in cars of the future any desired angle to the column, within reasonable limits, and also to vary the length of the column protruding from the dashboard.

A fracture of any part of the steering gear, especially when the car is travelling at a high speed, is liable to cause a serious accident, so that one should carefully examine the robustness of this portion of a car, more so a second-hand one, before purchasing.

*Irreversible Steering.*—The worm and sector mechanism provides what may be regarded as an irreversible steering; that is, the road wheels may be moved by the hand wheel, but not *vice versâ*, which is owing to the threads of the worm being practically at right angles to the thrust of the sector teeth. Usually, however, a slight back lash is present, which, if within limits, relieves the steering and the driver's hands and arms from small shocks. A perfectly rigid steering would mean that the front tyres, encountering the slightest obstacle, would transmit a corresponding shock to the wheel in its endeavour to turn it.

A reversible steering can be had if a crown and bevel wheel is used, but the lessened strain thereby present would be an element of danger, and likely to force the wheel out of the driver's hands at any incautious moment.

*Right- and Left-hand Controls.*—The position of the steering is always on the off or right side of British cars, where the rule of the road is to keep to the left-hand side; but on some Continental cars and several of American manufacture, where the right-hand side of the road is the right side in another sense as well, the left-hand control has been adopted, but in a few instances the levers are still on the right-hand side, which, in this case, is the centre of the car. On the other hand, in "right"-side-of-the-road countries, some drivers prefer their seat to be on the corresponding near side, since they are better able to keep the car well clear of ditches and other pitfalls on the edge of bad roads, while the left-hand driving position helps these motorists to judge the clearance between their own vehicles and those approaching from an opposite direction.

While these pages have been passing through the press, the French rule of the road has been altered so that it is now the same as on British roads.

# CHAPTER XXIV

## *WHEELS*

*The Function of Road Wheels.*—Road wheels transfer the road friction from their circumference to a centre which is well fitted and lubricated. Each spoke acts as a lever working round a common fulcrum, and the larger the wheel, and the smaller the axle, the higher the mechanical efficiency; but wheel diameter is largely restricted by the general design, and that of the axle by the necessary strength required.

The wheels support between them the whole weight of the car and its load, and have to withstand the strains and stresses of steering in front, the final drive of the transmission system at the rear, the various shocks from the inequalities of the road, and also the braking and skidding of the car.

They must, therefore, be thoroughly well designed and proportioned, and the quality of material and workmanship must be of the highest class, if they are to give satisfaction for any length of time.

The wheel of the horse-drawn carriage is made of oak or hickory spokes, tenoned into the mortices of an elm hub, and tanged into ash or hickory felloes or rims. For heavier classes of wheels oak is used for the hub, nave or stock, and various strengthening devices in the shape of hub bands, cut out to receive the spoke tenons, are utilized in all classes of wheels, while the size and number of the various parts are increased according to the estimated load.

*The Artillery Wheel.*—For the greater majority of motor vehicles the artillery wheel, as used on all types of military carriages, has been modified. This pattern does away with a wooden hub cut away to a mere shell, and the inner ends of the spokes are

mitred so that they all fit tightly together to form a solid centre, being arranged around an axle box, and held together by an inner and outer flange, the inner one being shrunk on to the box, the whole being held together by bolts passing through from back to front. Most artillery wheel spokes are tanged into a wooden rim, but although this appears to answer well in service, it would be a better plan to butt the spoke ends on to the rim, and hold them there by a suitably flanged collar, the two retaining screws of which would be less weakening than the tang hole.

Wheels being required in large quantities and at reasonable prices, machinery enters largely into their manufacture, a process which, with wooden wheels, does not always guarantee sound stuff being used throughout, for where a workman using his hand tool is naturally in a better position to notice the nature of the wood he is shaping, a machine simply does the work it is set to do, and does not hesitate to proceed if the timber reveals any unsoundness. The greater speed at which the work is done is also a factor meaning less inspection by the machinist, or the rejection by those responsible of faulty spokes or rims. The introduction of the solid rubber tyre in carriage wheel construction not only had the effect of lengthening the life of the wheel, but also of the body, so that with the more resilient pneumatic tyre there is no doubt that some badly made wheels last longer than they would if shod with iron tyres.

*Wheel Making.*—Ash felloes should be naturally seasoned, being cut roughly to shape as mentioned with the pillars and other framing in the chapter on body making. A felloe is that portion of the wheel circumference which receives two spokes only; rims or half rims embrace half the number of spokes of a wheel, and have to be bent by steam. The oak spokes should be cleft, that is, split with the grain, but they are sometimes sawn out of the plank to save expense. The spoke is cut to length, and has the mitres cut in a mitreing machine under a band saw. The body of the spoke is then shaped on a copying lathe, the operation being under the guidance of a roller which travels over the surface of an iron dummy spoke, a separate dummy being used for every different size and shape required. The spoke is then finished off on a glass papering belt, so as to prepare it for painting, after which the

round tang is cut for the joint with the felloe. The felloe is then planed on each side, cut to the right sweep and correct angle at the ends, and drilled to receive the tangs. All these operations will be performed on specially designed machines capable of adjustment so that a wheel of any size or number of spokes is automatically arranged for. After the spokes are assembled, the felloes are hammered on and the whole squeezed up in a machine, the outer faces trimmed up finally, white lead and linseed oil being used at the joints.

The tyre channel is cut to length, the amount required being found by running an iron disc, called a traveller, mounted in a forked handle, round the rim, a mark being made so that the point of starting is known. Allowances are made for the thickness of the metal and the weld. The joints of the felloes are left slightly open at the top, so that, as the channel contracts in cooling, they are brought together into a perfect butt joint, which is also held together by a wooden dowel. The channel is shaped in the rolls of a bender, and welded either with a butt or scarfed joint into a complete circle. The whole channel is then heated, and, while hot, laid over the new wheel, and quickly lowered into a tank of water so that the tyre naturally shrinks, and holds all together firmly.

Some charring of the rim is inevitable, though not to a detrimental extent; but for those who desire a cold process, the channel may be contracted by hydraulic pressure.

The heating of the tyre may be in a wood or coal fire, and the welding is often done electrically.

The channel is bored to receive the screws which assist in holding it to the rim, and also for the passage of the tyre security bolts and valve, if pneumatic tyres are to be used, while the centre is cut out for the axle box, and bored for the retaining bolts. Considering the pressure which is placed upon the woodwork when the tyre is put on, and the load carried under running conditions, it is essential that all the several parts shall accurately fit, and be uniformly strong throughout; otherwise the weakest joint and the least sound spoke will suffer, while indifferent workmanship may appear sound for the time being by reason of the force applied. With the hydraulic process it is essential that the machine should be under

the control of an intelligent workman. Many designs of wheels depend on the uniform quality of the material, and the perfect fitting of the joints, for their successful working, and a fault developing in one part leads to disintegration in other directions.

*Dished Wheels.*—If the stub axles are pitched, it will follow that a dished wheel is used, in which case the spokes are not parallel to the longitudinal axis of the wheel, but so arranged that as each spoke comes round to the lower vertical position it is at right angles to the ground line, and so supports the load directly.

A great deal has been written with regard to the dished or coned wheel, but no favourable argument has yet been supported by a proper series of trials between the upright wheel and this pattern. There is certainly the advantage of the increased strength to resist side strains, and the extra width across the top of the wheels for accommodating a wide body at the rear. Another advantage claimed is that mud is thrown more away from the body, but this is of little account with proper wings or mudguards, and it should be the desire of all road users to confine their car's mud spray to itself. When wheels are slightly dished the effect is more pleasing, since then there is no tendency for them to look as if they were falling in at the top; but when the front wheels are dished and the hind ones straight, the end view of the chassis is somewhat inartistic.

*Tangential Spokes.*—An important deviation from the standard type is the placing of the spokes tangentially to the hub in a wooden wheel. This is a better form, from the mechanical point of view, for the driving wheels, as the tendency is for the spokes to bend rather than to be compressed, with an accompanying reduction of shock; or in other words, the power is transmitted along, and not across, the length of the spoke. Spokes may also be assembled together by various interlocking devices, which assist in the construction of the wheel and tend to lengthen the life, as a faulty wheel will hold together longer; but the facility for repair is not always enhanced, while spokes are often staggered at the hub so as to distribute the load more evenly.

*Metal Wheels.*—Timber being a material whose soundness depends on so many circumstances has led to the increasing use of metal in wheel construction, where the quality is more under the control of human agency, and likewise a substance is at hand whose strength

is known more accurately, while its ability to withstand exposure is more marked in all climates.

Metal wheels are of various kinds. They may be built up of steel or iron, cast in one piece, or in parts, and afterwards assembled, pressed out, or made of wire spokes and metal rims. The cast-steel wheel has the rim and spokes cast in one with the hub, and great care is required, as with all castings, that the design shall allow of equal expansion and contraction while the wheel is being annealed. Such a wheel can be made very light in appearance, and need not exceed in weight that of a wooden wheel, while the spokes may be of tubular or cross section. Lightness is specially noticeable, as only eight spokes are required even for the hind wheel of a double-decked omnibus. Some patterns have wooden hubs in order to increase the resilience of the wheel.

The pressed steel wheel so closely resembles the artillery wooden wheel that a casual observer might easily be deceived when it has been painted. This variety is again no heavier than a wooden one, in fact somewhat lighter, and according to tests which have been made, considerably stronger. The critical test of a wheel is its ability to withstand sudden lateral strains, as when skidding, or taking a sharp curve.

The built-up wheel has the advantage of easy repair, which is not the case with some other varieties of metal wheels.

Pressed steel wheels have also been designed on the built-up principle. The spokes are pressed singly, and each tang is brazed on separately, while the rim is an electrically welded D-shaped pressing, and the hub a double steel shell with a wooden centre.

*Wire Wheels.*—Wire wheels, which were first used with success on racing cars, are, at the present time, gradually gaining in favour for touring cars. The spokes are tangential, and the stresses on the rim are evenly distributed, as there are usually sixty spokes in each wheel, more than the total of a set of artillery wheels.

The remarks which have been made with regard to metal wheels apply to this type also, and they possess the advantages of the built-up wheel. The artillery wheel has the tyre contracted on so that the spokes are in a state of compression ; in a wire wheel the spokes are threaded through the hub flange, and tightened by a nut at the nipple end on the rim, so that they are in a state of tension.

When the car is standing the lower spokes are compressed, causing a reverse state of affairs to take place on the upper half of the wheel, and when the car moves forward each spoke is gaining in compression and losing in tension as it turns round from top to bottom.

It is also necessary when building up a wire wheel to see that the tension is sufficient to withstand the forces acting in an opposite direction, otherwise an undue compression effect would cause the spokes to move at the end.

The Rudge-Whitworth wire wheel has been specially designed for motor-car work, and differs in many respects from the cycle wheel. The spokes are double dished, that is dished from either side, and capable of resisting side strains from either direction. In order that this dishing shall not interfere with the brake drum on some cars, a triple-spoked wheel is also made, which has a vertical series of spokes on the inside in addition to the double dished arrangement already mentioned. Another leading feature is the bending of the spoke end at the hub to an angle of about 45°, instead of the usual 90°, so that the strength of the straight spoke is largely retained.

The manufacture of a wire wheel is carried out in a highly ingenious manner by special machines. The hub is pressed to shape from a plain disc by a series of dies which gradually work it up into the required shape. The spokes are thicker at the bent hub end, and the thread is pressed, and not cut in so as to preserve the strength of the wire to the utmost. Holes are drilled in the hub flange slightly staggered, the holes in the rim being drilled while held in a universal jaw, so that the desired angle of hole for the nipple ends may be made. The inner set of spokes are attached to a hub flange of larger diameter than the outer set, which has been found to add to the strength of the wheel, since the extra stress in driving is taken up by the inner spokes, as, being shorter, their resistance to compression is greater, and on the other hand, the longer outer spokes perform the work of resisting side stresses from the outside. Much discussion has taken place as to the comparative merits of wire and wooden wheels, but so far as strength, weight, quality of material, and independence of climatic conditions are concerned, the wire wheel is certainly superior. The advocates of

the wooden wheel point out that it is more elastic than the wire wheel, and a better absorber of road vibration, and if a fair price is paid, the timber should be above suspicion, while appearance is on its side, but this last claim is a matter which is entirely a matter of personal taste. The wooden wheel, and metal types of a similar build, are easier to keep clean; on the other hand, the wire wheel is capable of adjustment should it be strained out of truth, but this is not possible with the artillery wheel. A far greater divergence of opinion lies between the advisability of using detachable rims as against detachable wheels, a matter which is dealt with in the chapter on tyres.

*Resilient Wheels.*—The remaining types of wheels are those which seek to do away with the expensive pneumatic tyre, and obtain resilience with a solid rubber tyre, and some means of spring device between the rim and the hub. The success of the air-filled tyre depends on the behaviour of a continuous air-chamber; this is difficult to reproduce by an arrangement of springs, which although they may imitate the displacement, provision has to be made for the recoil so that the pressure is continually altering. With a pneumatic tyre it is only the area of contact which changes.

With a resilient wheel, the mechanism must not be too delicate, otherwise it will not stand driving, steering and other strains. Several kinds of these wheels have been invented. Wheel resiliency is more effective when the absorbing medium is near the source of shock, so that the air cushion or spring should be close to the rim. Some patterns of spring wheels are to be condemned owing to the complications involved, which mean not only expense and weight, but liability to defective working unless every joint is well protected from the dust and mud.

Simplicity is essential because of the place of the wheels on the chassis and their ever-changing position as they revolve. Where resilience is gained by employing a disc, as in the Lynton wheel, this would appear to be in the right direction, and this wheel may be had in various spoked effects by those who think that a disc wheel spoils the appearance of a private car. Another simple plan consists in the use of an annular chamber surrounding the axle box, loosely packed with steel balls, through which the load is supported. When the car is moved the weight of the axle pressing down tends

to force the balls upwards each side, leaving a very small vacant space continually beneath. The road shocks being transmitted through the spokes to the special hub, the balls are for ever striving to return to the vacant space above mentioned, so that it is claimed vibration is absorbed without any perceptible reaction. This is the "shock-shifter" hub.

*Wheel Sizes.*—The diameter of the wheels influences several considerations with regard to the car. If two cars have equal wheel bases, but one is mounted on 34-in. wheels and the other on a set of 36-in. wheels, the chassis with the larger wheels will be shorter between the tyres on the same side, therefore there will be less room for the disposing of a side entrance body. Also two chassis of the same height from the ground but with different-sized wheels, will differ in the amount of wheel projecting above the frame, another point which may interfere with body design, especially if a wide and low seat is required.

A small wheel performs more revolutions over a given distance than a large one, but unless the two wheels differ considerably in height the increase of friction in the small one is not of great moment. The larger the wheel the more expensive it is to build and maintain, but in support of the high wheel some claim that a tyre of smaller section can be used, since the area of contact is greater, while the small wheel is at a disadvantage in negotiating inequalities in the road. High wheels are particularly useful where road conditions are primitive, and more so if it means that the frame is raised also, but this again has the effect of raising the centre of gravity, which is always undesirable in a speedy vehicle, and larger wings are required. Equal-sized wheels are useful from the economical and manufacturing standpoint, as spokes and felloes and other parts may be got out in large quantities to a set pattern, and tyres are interchangeable, so that one spare only need be carried. From the æsthetic standpoint wheels of equal diameter are open to some objection, as the optical effect is to cause the hind wheels to look a trifle smaller than the front, whereas the opposite arrangement is considered more desirable, although this may be the result of continually seeing horse-drawn vehicles so mounted.

# CHAPTER XXV

## *TYRES*

*The Outer Cover.*—The pneumatic tyres claim particular attention, since the amount of their wear and tear decides whether a car can be run economically or otherwise, and their freedom from break-down is now the chief factor in deciding the reliability of a car. The outer cover has a beaded edge of hard rubber, which fits into the channels of a clincher rim, with pliable sides or walls, and a thickened tread, the whole being built up on layers of canvas.

The inner tube is of rubber only, provided with a non-return air valve. This, when filled with air under pressure, keeps the outer cover in position, by which it is protected, provides the resilience, and the power to absorb the inequalities of the road. The outer cover is usually assisted in maintaining its proper position on the rim by means of two or three security bolts, the heads of which form a wedge against the inner walls of the beaded edge, or a valve may be used which combines the function of a security bolt as well.

As the tread of the cover meets directly with the surface of the road, its design and construction is the most important variation of the many kinds of tyres used. This part may be round, flat or square, or non-skid, a term which means that provision is specially made to resist the undue side movement of the car on slippery roads, while various methods of reinforcement are present in all patterns of treads designed to resist punctures and road friction of all kinds. The plain half-round tread is seldom used for the set of wheels, but often finds favour for the front wheels, where there is no driving strain, but its liability to skid has resulted largely in the adoption of the flat tread. This pattern, which is often ribbed and grooved, resists side slip, but in so doing more heat is generated.

The non-skid tread is greatly in favour for the driving wheels, and may have a leather or rubber band having steel studs, rubber studs, or various other designs of projections and depressions. The steel stud is objected to by some, on account of its wear on the road, but it wears longer than the rubber stud, although these will last 4,000 miles with care. Some forms of rubber projections wear a considerable time, but naturally a large amount of rubber is required in the tread.

*Inner Tube Protection.*—The vulnerable point of the tyre being the inner tube, the cover has to be inspected continually so that any defects in its protecting power may be immediately made good. Further safeguards have been recently invented, which seek to protect it by inserting an armoured tube, tube corset, or liner, which is wrapped round the tube and lies between it and the outer cover. It is essential that these devices should remain in the position where placed, that is, to be free from "creeping," and likewise their construction must ensure that no friction is set up between the delicate tube and the liner, or the constant rubbing will soon wear it thin. Holes in the cover, if of sufficient dimensions, allow the tube, which is under a pressure often of 60 and more lbs. to the square inch, to protrude and finally burst, which is a most disastrous accident, and a tube has been invented which, owing to its peculiar construction, is capable of resisting a large amount of internal pressure even when unsupported by the cover in position.

*Pneumatic Tyres necessary for High-speed Vehicles.*—The pneumatic tyre is necessary for a vehicle travelling at high speed, in order to give comfort to the passengers, and to preserve the vehicle. Although road vibration is partly absorbed by the springs, yet these are insufficient when travelling at more than fifteen miles per hour. Pneumatic tyres are useful up to a load of $2\frac{1}{2}$ tons, and may be used for such fast-moving vehicles as fire engines and ambulances.

For slower cars, such as commercial vehicles, and where upkeep is a vital point, the solid tyre is of great utility, and where great weight is carried, double and triple tyres are mounted on each hind wheel. The tyres should be proportional to the load, yet not of such excessive section that little work is demanded of the springs. Partly inflated tyres mean smoother running than those pumped up hard, but they will not last so long. The solid tyre requires a

chassis with the various parts designed with extra strength so as to withstand the extra vibration, and the tyre must be securely fastened so that it will remain firm under heavy loads. Tyres of all descriptions, owing to the constant rolling of the wheel, tend to leave the rim at a tangent, because of the centrifugal forces present, and any addition to the weight of the tyre, especially at the tread, increases the probability of its detachment.

*Solid Tyre Attachment.*—Pneumatic tyres are almost without exception retained in position by their beaded edges and security bolts, particularly now that the patent covering this means of attachment has expired. In a few instances the cover has been bolted on, but with solid tyres there are three or four leading methods used. These tyres may have an endless wire which has either been welded or drawn taut by left- and right-handed nuts; or be cemented at the hardened or vulcanite base to a steel band, which is bolted in various ways to the rim; or fastened by cross wires, or a combination of cross and circumferential wires.

Most solid tyres require a machine in order to fit them tightly, but sectional tyres may be had which can be fitted by hand.

*The Manufacture of Rubber.*—Indiarubber or caoutchouc comes chiefly from the valley of the Amazon in South America, or other parts of the world lying in the tropics, where an average temperature of 80° F., with a small variation, is a feature of climate. The substance, not to be confused with gutta-percha, is the milky juice or latex, as distinct from the sap, which comes away from various classes of trees on the bark being cut. Different systems are adopted for incising the trees and also collecting the juice, due regard being given to the amount of labour entailed, and the future existence and supply of the tree.

One method of preparing the rubber for the market is to transfer the contents of the various small collecting cups into a larger vessel, and then to hasten coagulation by a fire of palm nuts, the liberation of acetic acid and creosote causing the thickening up of the rubber. A paddle is dipped in and then held in the smoke of the fire until the lump solidifies, and by this means several layers are added until a sufficiently large mass is built upon the paddle, which is then cut off.

The crude rubber is passed through a washing machine, and

is pressed into various shapes to assist drying, and convenience of handling for export.

The tyre manufacturer often performs the washing and drying himself, as much of the wild rubber, in distinction to the cultivated varieties, is received in its crude state. There are also factories devoted entirely to the preparation of rubber.

After drying, the rubber is mixed with sulphur and other ingredients. Inner tubes should have only sulphur added, while outer covers and solid tyres have other ingredients added, such as oxide of zinc, which increases the toughness; powdered abestos, which gives heat resisting powers; while whiting, lead oxide, and carbonate of magnesia are added for other good reasons.

Absolutely pure rubber is useless for tyre purposes, and the nature and proportion of the ingredients added decide its subsequent elasticity and wearing properties. The drying, during which the rubber loses about a quarter of its bulk, is a tedious operation, but must be thoroughly carried out in darkened rooms, otherwise any moisture remaining will create porosity in the following processes.

*Making the Inner Tube.*—Inner tubes are made by cutting a strip of rubber sheet of the required size, and wrapping it round an aluminium mandril or core with a fine cloth, joining the edges with solution, and then curing and vulcanizing it in a bath of steam. Some judgment is required in deciding the length of time and temperature during this process. The patch which receives the valve may be inserted either in or out, the inside position making a neat and flush job less likely to set up friction. Inner tubes are also moulded in circular form so that they keep a better shape when deflated, while others may be constructed so that they naturally spring away from the security bolts when emptied of air, so preventing nipping, which is one of the chief causes of inner-tube damage.

*Construction of an Outer Cover.*—The building up of an outer cover takes some time, and although there is a less proportion of pure rubber in it, it will be readily seen why this part of the tyre costs double that of the tube. The cover is built up on a series of layers of absolutely dry cotton canvas, which is cut "on the cross," so that it leaves but little fulness in shaping it up around the bead. The cover being smaller at the edge than in the centre of the tread,

there would be considerable puckering of the fabric if it were laid in the direction of its length or weave, and moreover, a hole once started would easily be extended right round the circumference of the tyre. This placing of the canvas also gives it a better resistance to the rolling action of the wheel on the road.

The canvas plies are joined to one another, and as there are several in a heavy tyre, the manufacturer endeavours to make them as few as possible by using a machine which will treat the canvas in wide pieces during the calendering operation, which is carried out by frictioning or spreading. The friction calender has three iron rolls heated by steam, the centre one being driven at twice the speed of the others. The rubber is fed between the upper and centre rolls, and the canvas is passed between the centre and lower rolls, so that the rubber forms a thin coating on the canvas, owing to its higher speed and greater heat. The other side of the canvas is similarly treated. In the spreading process the rubber is laid on while in a solvent condition over the cotton, no pressure being used. The impregnating method devised by the North British Rubber Co. consists in passing the cotton repeatedly under pressure through a tank of rubber solution. After each immersion the cotton passes through hot steam chests, which immediately evaporate the solvent, while the thickness of the rubber solution is increased each time, and it is claimed that by so doing a rubberized fabric is produced.

The main difficulty lies in incorporating the rubber with the cotton, and the ideal method is the one which does this successfully with no danger of the two becoming separated in the subsequent stages of manufacture, or while the tyre is in use.

In the Palmer tyre carefully rubbered and flattened cords are used as the fabric on which the tyre is built. The cords lying parallel, and crossing each other at such an angle that they are tangential to the rim, therefore lie nearly in the line of strain, which falls upon all of them equally.

To revert to the ordinary practice, two or more layers of rubber-coated canvas are wrapped over a circular mandril, and the fulness which develops at the sides is smoothed out. The bead is then attached to each edge, which is made by being extruded or forced through a die of the required sectional shape. The beads must be

parallel, and of the proper shape, so that the clinches of the rim are filled without undue strain. A tightly fitting bead of hard rubber is often very difficult to detach.

So far the compound used, if a high-class tyre, is mainly rubber and the right proportion of sulphur, but in building up the tread the compounding is more complex, and the formula used may be regarded as a secret one. The strips of rubber coated canvas are calendered in rolls of the proper distance apart so as to regulate the thickness, and are put on similarly to the under layers, after which two strips of reinforcing canvas are laid on in the direction of the circumference of the tyre, thereby raising the tread in the centre.

The cover, so built up, is put into a well-fitting cast-iron case made in halves, then closed up, and subjected to a bath of steam (at a temperature of about 280° F., for about three hours, during which the sulphur melts) in the vulcanizing chamber, after which it is taken out and any superfluous rubber trimmed off.

If too great a temperature is used a brittle compound results which will easily split, a fact which should be remembered by those who endeavour to vulcanize their own tyres.

Separate bands of a non-skid character may afterwards be solutioned on, but generally it is better for them to be made up with the body of the tread so that there is no danger of them subsequently rolling off when in use. The tread of the tyre should be always more or less under compression, so that any small cut made in it is self-closing, otherwise likelihood of the pinching of the tube is more certain.

*Solid Tyre Manufacture.*—Solid tyres are made by forming the rubber compound into a workable mass by hot rolling, and then forcing the stuff through a die as with the making of the bead, the ends being cut so that a spliced joint can be made.

When the base of the tyre is embedded in a vulcanite base, the proportion of sulphur to rubber is increased gradually, so that the character of the rubber allows it to be easily incorporated with the tread above, while below the greater amount of sulphur provides a hard variety of rubber which may be more readily attached to the metal band, which is cleaned and carefully brushed with solution for that purpose. The built-up or plain solid tyre is then placed in moulds and vulcanized.

The ideal tyre should have its ingredients evenly distributed, and the various batches of material should be alike so that the brand of tyre is dependable. The careful manufacturer will endeavour to use such materials as increase the weight of the tyre to a minimum extent, and have as little effect upon the surrounding rubber as possible.

*Tyre Manipulation.*—The fitting and detaching of pneumatic tyres on the wheel rims is considered by many as a rather laborious process, but the correct way of carrying these operations out must be fully understood, otherwise an expensive tyre may easily be damaged.

Those who are cyclists will need little advice, as the process is much the same coupled with the expenditure of a little more energy. The tools required are a jack to raise the axle from the ground, and two or more levers of various patterns, together with a pump and a supply of French chalk, a white powder, soapy to the touch, which is useful for preventing the rubber surfaces sticking, and therefore acts as a dry lubricant. The repair outfit must, of course, not be forgotten, which will include a supply of different sized patches, a tube of solution, valve pins (the vital part of the valve), washers, a small brush for cleaning the repair, and a gaiter.

*Attaching the Tyre.*—Wipe the rim round once or twice so as to free it from any possible grit, and if a wire wheel, see that no spoke ends are projecting; if so, these must be corrected before proceeding farther. The normal rim has two or three smaller holes for the passage of the security bolts, and a larger one for the air valve. The work is then rendered easier by a moderate use of the French chalk, which should be wiped over the beads, and inside of the cover, and over the tube, and not scattered loosely around, because an excess defeats the object in view, as lumps will be formed which will set up friction between the cover and the tube. The tube may be first inserted in the cover, and then taken to the wheel, or what is perhaps a better method the cover is partly attached and then the tube inserted afterwards. Taking this method the wheel is turned so that the valve hole is at the top, the cover at the valve slit is presented at the valve hole, and then the bead nearest the car is inserted as far as possible by means of the hand placed inside, the operation at the inner clinch being finished by the lever or

levers, according to the particular pattern used, each leading tyre firm having its own special shape, which is designed to facilitate the work, and prevent injury with a minimum of dexterity. Some advocate that the security bolts shall be placed in position loosely immediately after cleaning the rim, but if not done so then, they must now be carefully inserted, during which process the fork lever is extremely useful, that is, a tool which has two prongs, thereby enabling a fairly wide section of the loose bead of the cover to be lifted, the bolt being inserted between the prongs, and repeating the operation at each bolt hole. The tube which is to be used must be quite flat, and an additional precaution is to see that it is quite sound. If the tube shows signs of contained air, the valve should be undone, and the deflation carried out by rolling the tube up from each side towards the valve, afterwards fastening up the valve again. The tube is then taken to the wheel, and the fork lever inserted centrally over the valve hole, the valve pushed through, and the tube inserted well under, and into the cover. The remaining portion of the tube is then gently arranged round the rim in sections by pulling the outer loose bead with one hand and tucking in the tube with the other, no straining or pulling being used to get the tube into position, and when it fully encircles the wheel it should be tested with the hand to see that there are no creases present. When the tube is placed in the cover first, it is usual to slightly inflate it with a few strokes of the pump, but in the method described here, this will be done now, and if the tube does not feel smooth to the touch it is a sure sign that the work has been improperly done, and it is advisable to start all over again by deflating and gently withdrawing the tube. The outer bead has now to be placed in position by means of the lever being inserted under it, and lifted up so that the bead is scooped into the clinch. By using two levers a longer section of the bead may be treated at a time, and if a hooked lever is used in conjunction part of the bead may be retained in position while the remainder is being dealt with.

Each of the security bolts being loose they should be free to move inwards towards the tread of the cover; if not they are nipping the tube, or else wedged under, instead of over, the bead. The attachment of the tyre can also be assisted by the hand being grasped over the cover. The tyre is then fully inflated, according

to the table given, by means of three hundred or four hundred strokes of a foot pump provided with a gauge, and finally the bolts and valves tightened up by hand. A tyre may also be pumped up by a suitable attachment made to the exhaust, or by way of the air inlet of the carburettor, so that in either case the engine is called upon to do the work.

Other ways adopted are by means of compressed air, which may be purchased in iron bottles, and by sparklets, which generate gas similar to the methods adopted in making aerated water at home.

*Detaching the Tyre.*—In most cases this will be the motorist's first experience of tyre manipulation. The tyre is first deflated, and the bolts unscrewed, and the outer bead treated with the levers, which are worked in the opposite direction to that adopted during attachment, and when arriving at the valve, or any of the bolts, these are pushed up so as to be free from the bead. During the first part of the releasing of the cover the levers must not be held too far apart, or too near together, otherwise the bead will not move, or, on the other hand, the bead will slip back again.

The tube being in the cover the end of the levers must be kept carefully away from it. The tube is removed by inserting the prongs of the fork lever as before over the valve, so that it and the rest of the tube can be released from under the loose bead. The further bead of the cover is then detached by pulling the cover towards the operator assisted by a flat lever.

To acquire proficiency the motorist cannot do better than acquaint himself with the actual operation, receiving instruction from an expert garage hand, and, if possible, practising with an old cover and tube, or he may avoid the greater part of this tedious process by having his car fitted with rims which allow of much easier taking off and putting on, as are described later in this chapter.

The leading points to keep in view are slow, deliberate, and systematic operation, with due regard for a minimum of well applied chalk, and the life of the inner tube.

*Tyre Preservation.*—The tyres should be kept away from all grease and oil, agents which have a solvent effect on the rubber, while water, if it gets at the canvas, will rot it. Therefore the

car, whether in the garage or standing in the road, should be kept away from puddles and oil droppings. The security bolts and valve should fit well into their holes, and be screwed home so that water cannot enter the rim, also the tyre should be wiped after the car has been washed.

The faster a car travels the greater the friction and the accompanying heat generated, which is again a destructive factor, and as has been pointed out, this also depends on the flatness of the tread, and the degree of inflation. On the other hand, some punctures are avoided by fast driving.

The metal rim should be kept properly painted so that no rust can accumulate, otherwise a jagged edge will be formed, which is detrimental to the bead. The rim must be true, that is with parallel clinches, the whole forming a true circle, while wheels must be truly set on the axles, and tight in all their joints, so that there is no undue strain on the tyres.

The life of the tyres is further ensured if they are suited to their work as regards section and substance for weight carried, and also due attention paid to their proper inflation. They should be periodically inspected, and any slight defect remedied at once. Abrupt stopping and starting, and quick turning, all assist in shortening the life of the tyre.

*Tyre Repairs.*—Only the smaller repairs are undertaken by the motorist, such as patching small punctures, and filling up small holes in the cover. The cover is repaired after removal with bevelled rubber and canvas patches, an inch larger all round than the hole, which has been smeared with solution, allowed to dry, and then applied to the inside of the cover, over which it is usual to lace a gaiter until the damage can be permanently repaired by vulcanizing.

Tubes are mended with a bevelled rubber patch, and in each case French chalk is used to dry up the edges of the work. A thickened variety of solution can also be obtained, which is useful for plugging holes in the tube, and spreading over the defects in the cover.

Serious tyre repairs are done by the manufacturer, who has a special plant at his disposal as well as the necessary experience. Many garages are now equipped with electric, steam and flame

vulcanizing apparatus, where such patches which have been applied on the road can be substituted for a proper filling up of the damaged parts.

Inner tubes will have their punctures properly vulcanized, and it may be necessary, in the event of a bad burst, to insert a new section of tubing. Vulcanizing, as carried out by the motorist himself, or in the garage, is a copy of the processes, on a small scale, of the tyre maker. The hole is well cleaned and trimmed with a bevel all round, roughened with glass-paper or a wire brush, so as to give a grip to the new material. The hole being quite dry, four coats of solution are given, allowing time for each coat to dry; the new rubber is pressed in and smoothed over with a roller, the excess being sliced off with a wet knife.

Vulcanizing takes about thirty minutes at the temperature already stated. Heat may be dispensed with by using a preparation consisting of bi-sulphide of carbon (a solvent of rubber) and chloride of sulphur, which is applied to the surface under treatment, and takes the place of the vulcanizing.

Special patches are used which have an unvulcanized surface.

Vulcanizing is much preferred to ordinary patching, as the repaired and surrounding portions of the tyre are, as it were, welded together, whereas with patching the parts are simply bridged over, which cannot be so strong or satisfactory as filling up the hole completely, making it flush with the original tyre substance both in and out. After repairs of any sort, the tyre will give better service if it is allowed to rest for three or four days, so that the motorist will find that economical running is bound up with a reasonable supply of spares.

Tyres, as they wear, should be watched to see that the tread does not become too thin, as a well-made outer cover can be re-treaded, which doubles the life of the tyre at the price of less than a tyre and a half.

Spare covers should be protected from the light, as well as from oil and water, by being kept in a waterproof case, and the position chosen should be as cool as possible. Tubes require the extra precaution of being kept away from anything which may rub them, and the best receptacle is a waterproof bag which has had the interior rubbed over with french chalk, such bags being kept

by themselves, or in a partitioned-off space in the locker or tool box.

*Mileage.*—Owing to great variations in road surfaces, the care taken in driving, and other considerations, it is difficult to predict the life of a cover before re-treading. Perhaps 5,000 miles is a good average, while more than three times that amount is claimed for high-class solid tyres.

Solid tyres may be purchased guaranteed to give a mileage of 10,000 in a year, but this way of buying naturally imposes various restrictions, such as maximum weight carried, type of road run on, and periodical inspection; but it may be safely assumed that if the vendor can afford to guarantee tyres for 10,000 miles, with fair usage, they will actually last longer still.

*Tyre Pressures and Loads.*—It is useful to know the proper degree of inflation, as this is an important factor in lengthening the life of the tyres. The weight of the car is ascertained by pushing it on to the centre of a weighbridge with one pair of wheels off the machine, and repeating the operation with the other set of wheels, so that the weight on each axle is known.

The following is a table of average pressures which are suitable:—

| Size of tyre section in millimetres. | Weight in lbs. to be carried by *each* tyre. | Air pressure in lbs. per sq. inch in tube. | |
|---|---|---|---|
| | | Hind wheels. | Front wheels. |
| 65 | 380 | 50 | 42 |
| 75 | 450 | 55 | 48 |
| 85 | 550 | 60 | 52 |
| 90 | 750 | 70 | 62 |
| 100 | 950 | 75 | 70 |
| 105 | 1050 | 75 | 70 |
| 120 | 1200 | 75 | 70 |
| 135 | 1350 | 75 | 70 |
| 150 | 1500 | 75 | 70 |

If tyres which are built up lighter are used on the steering wheels, the pressure may be some 10 lbs. less, while the pressure should be increased if the load is beyond that specified above. If the load is increased 10 per cent., then the tyre pressure should be

approximately 2 per cent. more. The car should be overtyred rather than undershod, the increased outlay being compensated for by the additional mileage obtained.

It should be remembered that the above figures relate to the load per wheel, so that they must be doubled to ascertain the axle load which has been previously arrived at on the weighbridge, the car being fully equipped, and with its full complement of passengers.

The various loads per axle suitable for solid tyres are as follows :—

| To carry a total load of | On front axle about | On hind axle about | Size of front tyres. | Size of hind twin tyres each. |
|---|---|---|---|---|
| $2\frac{1}{4}$ tons. | 15 cwt. | $1\frac{1}{2}$ tons. | 65 mm. or $2\frac{1}{2}''$ | 65 mm. |
| $3\frac{1}{4}$–$3\frac{1}{2}$ tons. | 20–22 cwt. | $2\frac{1}{4}$ ,, | 75 ,, ,, $3''$ | 75 ,, |
| 4 tons. | $1\frac{1}{4}$ tons. | $2\frac{3}{4}$ ,, | 85 ,, ,, $3\frac{1}{4}''$ | 85 ,, |
| $4\frac{1}{2}$ ,, | $1\frac{1}{2}$ ,, | 3 ,, | 90 ,, ,, $3\frac{1}{2}''$ | 85 ,, |
| 5 ,, | $1\frac{3}{4}$ ,, | $3\frac{1}{4}$ ,, | 100 ,, ,, $4''$ | 90 ,, |
| 6 ,, | 2 ,, | 4 ,, | 100 ,, ,, $4''$ | 100 ,, |
| 7 ,, | $2\frac{1}{4}$ ,, | $4\frac{3}{4}$ ,, | 110 ,, ,, $4\frac{1}{4}''$ | 110 ,, |
| 8 ,, | $2\frac{1}{2}$ ,, | $5\frac{1}{2}$ ,, | 120 ,, ,, $4\frac{3}{4}''$ | 110 ,, |
| 9 ,, | $2\frac{3}{4}$ ,, | $6\frac{1}{4}$ ,, | 120 ,, | 120 ,, |
| 10 ,, | 3 ,, | 7 ,, | 140 ,, ,, $5\frac{1}{2}''$ | 120 ,, |
| 11 ,, | $3\frac{1}{4}$ ,, | $7\frac{3}{4}$ ,, | 140 ,, | 140 ,, |
| 12 ,, | $3\frac{1}{2}$ ,, | $8\frac{1}{2}$ ,, | 160 ,, ,, $6\frac{1}{4}''$ | 140 ,, |
| 13 ,, | 4 ,, | 9 ,, | 160 ,, | 160 ,, |
| 14 ,, | 5 ,, | 9 ,, | 160 ,, | 160 ,, |

*Tyre Sizes.*—The diameter of the tyre is usually expressed in millimetres, likewise the measurement across the sectional area or width over all the tread. These sizes are usually approximate only, and differ slightly with various manufacturers. There is a bewildering array of different sizes of tyres placed at the motorist's disposal, which on the face of it would appear to be unwise, especially with a detachable device. One may obtain covers and tubes ranging from 650 mm. ($25\frac{5}{8}$ ins.), rising in graduations of 50 mm. (2 ins.) to 1050 mm. ($41\frac{3}{8}$ ins.), with odd sizes between, and different sectional areas, so that a large firm can offer a selection of over 40 different sizes of tyres, which does not always ensure that the motorist, stranded in a small country town, can obtain at once his desired new cover or tube. No doubt this has been the cause of

the adoption of equal-sized wheels, although this again is defeated to an extent if the car has non-skids at the rear. However, 5 mm. ($\frac{3}{16}$ in.) difference in the section of a tyre can be used for the same rims, and the cost ranges from £3 6*s.* for a light tube and cover (650 × 65) up to £9 15*s.* for a heavy steel-studded complete tyre (1050 × 150). The largest tyres so far adopted for touring cars are 180 mm. or 7 ins. in width. Small tyres are naturally cheaper in first cost, but the larger and wider the tyre the greater the comfort and power to travel over bad road surfaces; but, on the other hand, a wide tyre is a dust raiser.

*Detachable Rims, Flanges and Wheels.*—Tyre removal and refitting is a tedious job, which is rendered, on a rainy day on a muddy road, when time is valuable, to say the least, objectionable, so that it is not surprising that various devices have been invented which are designed to minimize this, or defer the operation to a more convenient time and place.

Foremost among the inventions which allow the motorist to continue with his damaged tyre, is the spare rim or wheel known as the Stepney spare wheel. This is carried on the off-side long side step, preferably in a metal well, and when wanted for use is removed from the claws of the tyre carriers and offered up to the wheel rendered *hors de combat.* Three or four strong hooks are provided on the Stepney wheel, which are engaged with the rim of the deflated tyre by pushing the cover inward, and then screwing up tightly and not opposite the security bolts, while as a precaution, straps are used coupling the spokes to bollards on the spare rim, so as to prevent any creeping. These wheels may be purchased with expanding and contracting hooks, so that a car shod with larger wheels at the rear may be served by one spare wheel, and where tyres are used which have very stiff beads, or if an armoured tube is used, it may be attached to a specially mounted rim secured to the felloe of the normal road wheel. The device is applicable to wire wheels, and it may be adopted simply as an extra non-skid should the motorist desire to alter the character of his tyres without troubling to change the existing covers. This is a cheap and simple device, and entails a minimum of complication.

The spare wheel may also be attached by clips fastened directly between the spokes, and in order that it shall always be dependable

it is wise to use only sound covers and tubes on the spare wheel, so that it is always ready for use. As the device increases the normal track of the car, the usual mudguards are insufficient in width, and a temporary side attachment may be utilized which buttons on to the outside of the existing wing.

The remaining contrivances may be classed under the headings of detachable wheels, rims, and flanges.

The detachable wheel is made possible by providing the axle arm with a double shell to the hub, the permanent hub having projecting pins which transmit the drive from corresponding holes in the wheel hub, or by means of keys engaging with slots. The wheel is retained in position by a cap screwing into an extension of the inner hub, usually a rachet device being adopted which securely locks the wheel, and in some cases the wheel is automatically removed as the cap is unscrewed by the special spanner, and *vice versâ*. By means of the spare wheel a ready inflated tyre may be carried, and the change when made is permanent until the next puncture. The advantage gained is that there is no need to reinforce the wheel at the rim, but only at its smaller part—the hub, but the complete spare wheel is naturally heavier and bulkier to carry. A wheel is usually easier to carry than a rim, but often four wheels with detachable rims and a spare are heavier than a corresponding set of detachable wheels.

The detachable rim may be had in many varieties, for both single and twin tyres, pneumatic or solid. It usually entails a bonding band, sometimes bevelled to provide a wedging surface, to keep the spokes in place while the rim is removed, and the pattern adopted should be carefully designed so that wet does not easily get in and cause rust, so preventing detachment when required, and it is an advantage if the security bolts are readily accessible. It is advisable to remove detachable rims, say once a fortnight, in order that proper lubrication with castor oil shall be ensured. Some rims, by reason of their being split circumferentially or into segments, allow of particularly easy detachment, and attachment of the tyre, which is a considerable advantage, as it is even more difficult to fit a cover to a flimsy rim unless it is mounted for the purpose on a specially designed stand, which may form the dual function of carrier and tyre changer, because, whether rim or wheel, the cover has eventually to be

removed. Care must be taken of the rim when off the wheel, so that it does not get twisted out of truth. Some rims have an expanding and contracting device which aids in their operation, eccentric mechanism usually being adopted.

The device made by Messrs. Moseley and Sons consists of an outer cover with wired edges, a specially shaped rim, which receives on its outer edges a retaining band or tube, cut through at one point, and fitted with a turn buckle, over which a hinged portion fits. This turn-buckle is operated by a tommy bar, so that the retaining piece may easily be contracted and expanded, thereby making the removal of the tyre a simple matter.

Detachable rims and flanges are often retained, either by bolting through the felloe, or by blocks specially provided for the purpose, coupled with a wedging attachment working between the bonding band and the rim clinch.

For those who object to the spare wheel or rim impeding the entrance to the driver's seat from the offside, a compromise may be effected by mounting the wheel farther forward, the scuttle dash, if used, being specially shaped to receive the tyre. Also the spare may be carried in a hinged carrier, so that it may be swung open like a gate when necessary. Other alternatives consist of mounting the wheel at the rear, or in a special tray at the rear, those chassis which are wider between the springs than the height of the wheel being specially suited for this purpose, or it may be strapped on the roof if it is a covered car. If two spares are necessary on a long trip, a tyre should be chosen which is compact in its cross section, a point on which some types of wire wheels fail, care being taken to see that no part of the tyre or wheel chafes against the body of the car or its fittings.

It may happen that an unfortunate motorist has expended all his resources in spare tubes and covers, and is stranded on a deflated rim, which may sometimes occur to those who are forgetful, and leave various necessary items behind in the motor house. The best plan is to ride on the bare rim slowly or else take out the tube if the tools are not forgotten also, and stuff the cover with any available substance, such as grass, clean rags, and so on.

*Tyre Fillings.*—Apart from the use of detachable rims and wheels to decrease the nuisance of tyre changing, there has been

some activity in providing means for preventing rather than curing the trouble of punctures. Mention has already been made of the use of armoured inner tubes, but in addition to this, the inner tube may be done away with and various fluids injected into an air-tight cover, which become, after solidification, more or less spongy and elastic. Some of these compounds have the disadvantage of becoming soft and useless under the rolling action of the wheel and the load, besides working up into flat places. Most of them are unaffected by small punctures, but should a serious one happen, or if it is required to change the cover for any reason, the filling has to be renewed. The filling is usually a little more expensive than the ordinary inner tube, besides slightly heavier—a few pounds—per wheel. These fillings, by reason of their weight, tend to stretch the cover, and they demand a special lining to the cover so that it shall be reasonably air-tight.

Fluids and powders are sometimes forced through the ordinary valve to fill small punctures, and prevent the air from escaping. On the whole, they have been found satisfactory, and allow of the proper tyre repair being delayed.

The tyre filling compounds usually contain glycerine with the addition of gelatine, sugar, silicate of soda, indiarubber, starch, plaster of paris, whiting, chalk, magnesia, and other chemicals.

*Cushion Tyres.*—A compromise between the pneumatic and solid tyre, which has some of the advantages of both varieties, is the cushion tyre. Various forms of moulded separate air-chamber pneumatics might be classed under this heading, but the usual pattern consists of a solid tyre with a hole or holes formed near the base, or the tyre may be in the form of an arch, or be pierced in other ways. These tyres are naturally heavier than pneumatic tyres, but are lighter than solids, have immunity from puncture, and are specially suited for fast-running commercial vehicles. If the air chamber is large, a canvas foundation may be added to give strength. The Torkington tyre is a solid tyre having a chain or articulated band embedded just below the centre, by which it is retained on the rim, and the normal section is $3\frac{3}{8}$ ins. deep from tread to base, which exceeds considerably the usual dimension of this class of tyre. It has been adopted for taxicabs, where the cost factor is a serious problem.

# CHAPTER XXVI

## *SPRINGS*

*The Function of Springs.*—The springs on which the car is suspended are provided to minimize the shocks the moving vehicle is repeatedly meeting owing to the inequalities of the road. Broadly considered, the springs perform the same function as in a horse-drawn carriage, the extra road vibration set up owing to the greater speed being absorbed by the rubber tyres. A smoothly travelling car means comfort for the passengers, longer life to the several parts of the chassis and body work, and economy of engine power. The springs form the direct connection between the frame and the axles, so that the shocks, transmitted by the wheels, pass through them, and are absorbed in varying degrees by the springs, according to their design and material.

*Types Used.*—A spring is made up of a number of thin plates of steel in contact of different lengths, and the following varieties are used :—

(*a*) The elbow spring. This is supported at one end and carries the load at the other. It is the simplest type, and may be considered as the one from which all the other patterns have been evolved. It is seldom used alone in automobile construction, but is well suited to cars of special design, such as New Engine Co.'s car, where the whole body is well within the wheelbase, while there are a few cars of the ordinary type suspended at the rear on elbow springs.

(*b*) The side, half or semi-elliptic, grasshopper, horizontal or double-elbow spring. This is the most popular variety used, especially for the front axle ; is the easiest and cheapest to mount, and if properly designed gives the most satisfaction. It is supported at its centre on the axle, and carries the weight at either end. An

inverted half-elliptic spring is often used as a cross spring joining two side springs by means of shackles to form the hind suspension of the chassis, Such a combination of three springs is widely used on two-wheeled horse vehicles of all descriptions, and is the typical mounting of the Dennett gig. Sometimes this arrangement of springs is called a " platform " suspension, but this is strictly the name given to a rectangular combination of four springs, two side and two cross, as used with a four-in-hand drag. A cross spring alone is used sometimes for the front suspension, as in the Rover, Sizaire-Naudin, and some racing cars, so that a balance, or three-point suspension, is obtained.

(*c*) The elliptic spring. This consists of one side spring inverted over another. The road shocks are transmitted from the lower to the top half so that a greater degree of resilience is given. This type is supported in the centre of the lower half, and receives the weight directly over it in the centre of the top half. This method of attachment is less satisfactory than that of the side spring, which has two points of fixing to the frame. The depth of this spring overall does not allow of a low-hung chassis unless special provision is made. It has been, and is used on a few cars for the hind suspension, and there are varieties having scrolls and shackles either at one or both ends.

(*d*) The three-quarter elliptic spring. This usually has a scroll to the hind end, and is a combination of an elbow and a side spring. It is very fashionable for the hind suspension, and allows of the use of a shorter frame, as with an elliptic spring, but it is liable to be weak at the scroll, is often so badly placed as to interfere with the bodywork, and has little advantage over a properly made side spring except the greater length more compactly arranged. This is the main argument advanced for the use of all springs in combination, and in the case of two side and a cross spring, as seen in the hind suspension, this is apt to set up side sway owing to the freedom allowed at the shackles.

(*e*) The C spring. This, if a true C spring, is used in addition to the usual chassis springs, to give extra comfort by reason of the body being suspended by leather braces. The body may be hung at the rear on a pair of imitation C springs, in which case the body is not isolated from the driving seat. The chassis being seldom

designed for these springs, the hind pair are usually unsightly in their isolation, while, owing to the exigencies of the chassis, the front ones have to be placed much lower than the hind ones. The more upright a spring is, the less ease it gives, so that C springs are not in themselves ideal, but the luxurious suspension obtained is owing to the shocks having to be transmitted, first, through the lower springs, and then by way of the C springs and the leather braces on which the body is suspended. It is usual to provide means so that the body sway shall be within limits. As the body is hung between the braces, this corresponds to the ideal hanging, that is, the weight or load is between the points of support. Other patterns of springs on a chassis generally mean that most of the load is over the support.

When an obstacle is encountered on the road a spring moves upwards or away from it, first quickly, and then slower, until it momentarily comes to a state of rest, after which it again moves downwards or in the opposite direction, the movement of the spring being accelerated, the loss and gain of speed in either case being largely controlled by the friction set up between the spring plates.

Other combinations of springs are those which have scroll ends, and arrangements of spiral and helical springs, which are placed so as to absorb the smaller shocks, or to dampen the effect of larger ones before or after they reach the main springs. Helical springs may be mounted at the eyes so that torsional strains are resisted, at the centre of the spring in the nature of a check (such as is commonly used in horse-drawn vans, although laminated varieties are often used in this instance), and incorporated with the shackle movement, this last type being favoured on many American cars and on the English Daimler chassis. Shock absorbers, mounted between the axle and the chassis frame, perform the function of auxiliary springs, but their action usually depends on friction rather than deflection.

A few patterns of pneumatic devices have been invented which seek to isolate the body from road shocks by the action of a piston working in a cylinder of air. Such an arrangement is lighter than a corresponding set of springs, and it is even claimed that solid tyres may be used, but the hind cylinders interfere somewhat with the lower body construction. These pneumatic and other devices,

however, make excellent auxiliary springs, as they control the movement of the main springs, which may be important when travelling over bad roads, or if it is a style of body in which the clearances between the tyres and wings are limited. Further comfort for the passengers, in any case, may be obtained by the method employed in mounting the bottom frame of the body on the chassis, and the construction of the seat cushions, and other parts of the trimming.

*Methods of Attachment.*—The spring is attached to the axle by means of two clips, which pass round the bundle of plates, the screwed ends of the clips passing through the holes drilled in a flap forged in the solid with the axle, or its equivalent afterwards attached. A rivet is inserted to keep the plates together in the centre. The ends of the spring are attached in various ways according to their design. With the side spring, the extreme limits of the side members of the chassis are largely dependent on the length of springs to be adopted, although separate dumb irons may be attached, and, if the axles are towards the ends of the chassis, it will mean a great amount of projection at each end, if long springs are to be used. The inner ends of the side springs are fastened in various ways; usually there is a lug or eye, which may be fastened under the bottom flange of the frame for the front suspension, or by a small plate to the web of the frame, for both the front and hind springs. Three-quarter and full elliptic springs, when used for the rear suspension, require their upper portions to be fixed by means of some special bracket to the top flange of the frame, or it may be so arranged that an extension of the hind cross member performs that office. This method of fixing also ensures that the hind springs are well out of the way of the bodywork.

When the load is applied to the spring it is said to lengthen, or what is perhaps more correct to say, it assumes an outline of greater radius, consequently the two ends are farther apart, unless the spring is compassed at either end, then the gain in length is very little. To allow for this end movement, one or both ends must be given freedom to move. With a side spring the hind end is shackled or coupled to a second centre, and in an elliptic spring its construction entails the use of a hinge at either end. The parts of a shackle should always be in tension, so that in hanging a spring, the shackle must be so arranged that when unloaded the straight line drawn

through the two centres of the shackle leans inwards towards the centre of the spring, and when the maximum load is on, the line, just mentioned, should not be beyond the perpendicular. If the shackle centres are above one another when the car is empty, it will probably mean that when loaded, and the car meets with a large obstruction on the road, the shackle will be forced against the scroll or other iron which supports it, or else be jolted over into the reverse direction of its proper working. In place of this type of shackle, a variety of universal joint may be used which allows of a similar amount of movement to that of a **D** shackle as adopted in the hind suspension when two side and a cross spring are used.

Springs are not mounted quite horizontal, but pitched down at the back end about one inch. This enables the spring to meet the shocks more squarely, and prevents the chassis dipping down in front. It has also been recommended that the front springs should be mounted with the greater half towards the rear, so that there is less spring movement in front to influence the steering, while an opposite arrangement is suggested for the hind spring when there are no radius rods. Radius rods are used to keep the axle in its proper relative position to the frame, and when they are absent, it imposes an extra strain on the back plate of the hind spring, causing it to straighten towards the back end. It is an advantage if the spring has freedom to swivel about its support, especially with a live-axle car, as the turning movement is constantly pressing against the front end, a problem which does not occur with a horse carriage, which is practically a trailer car behind the horse.

Apart from the considerations just mentioned, the ideal to strive for would seem to be that each half shall perform its work without any tendency to pull on the axle or revolve it, which strain must be present if the two halves are working unequally. With a spring which has a fancy scroll, it becomes difficult to decide where to divide the spring so that a balance of forces shall be preserved.

The camber or span given to the spring controls to a large extent the height of the chassis from the ground. A low step may be obtained by cranking down the frame in the centre, but another method is to place the frame below the springs, or to put the springs below the axle as in the Renault car.

*Spring Steel.*—The best Swedish iron is the most suitable material

from which to make spring steel, as it is made from ores purer than our native ones, and is smelted with charcoal, which has less sulphur and other impurities in it than other fuels. The steel is made by the cementation process. The wrought iron is hammered into flat bars, which are heated for several days at a temperature of about 1400° F. in contact with charcoal in boxes, the tops of which are cemented to exclude air. The cemented bars, which are brittle, crystalline, and more or less covered with blisters, hence the term "blister steel", are broken, sorted, melted in a crucible at an orange-red heat, and with proper precautions, poured in prepared moulds, so as to form ingots which can be rolled or hammered into the shapes desired. The longer the process is continued, the higher the percentage of carbon the steel will contain.

*The Cementation Process.*—In the cementation process the carbon is first taken away from the pig iron, and then about half of it is put back again, or in other words cast-iron is made into wrought-iron, and then into steel by re-carbonizing it. The difference between steel and pig-iron or cast-iron is not a clearly defined one, but it is convenient to say that it depends on a certain proportion of carbon, and with steel the capability of being hardened and tempered. The proportion of carbon in steel may vary from $\frac{1}{2}$ to 2 per cent. The cementation process is carried out in a furnace which has a cone-shaped roof, and is rectangular in shape. Herein are placed the brick converting chests, while a fireplace is arranged underneath and between them, the flames being distributed by means of flues. The chests are filled with alternate layers of charcoal and bars, a layer of charcoal being at top and bottom, over which a cementing layer of siliceous material is finally placed. The process takes from a week to a week and a half, according to the character of steel required.

*Special Spring Steels.*—Chrome-vanadium and silico manganese steels are now often used for the springs of high-grade cars. Vanadium steel is an excellent material to use, because it is tough and strong, and is not so liable to snap as carbon steel; in fact, it is claimed that an overloaded spring will only bend should it from any cause be so treated. All the chrome-vanadium steels have the power to resist the crystallizing action of long-continued use. The amount of heat used, the period over which the temperature is

maintained, and the method of tempering used, are all the result of much scientific investigation, and the materials used in this and other parts of the chassis have assisted very largely in making possible the reliable and low weight-per-horse-power cars of to-day.

Chromium in small quantities raises the tensile strength of the steel, vanadium has a similar but more powerful influence, and increases the elastic limit. In all cases the right proportion has to be properly controlled, as an excess has the effect of defeating the object in view. Vanadium alone does not alter the steel much, but when the chromium is added a distinct improvement in the character of the metal results. When melting the charge in the crucible the chromium is added first, the vanadium following when the metal is about half melted.

Ordinary spring steel has the following composition per cent., in addition to the iron contained:—Carbon, 0·5 to 0·6; silicon, 0·2 to 0·3; manganese, 0·4 to 0·7; phosphorus, 0·04 to 0·07; sulphur, 0·025 to 0·05.

Special steels must be as free as possible from nitrogen and phosphorus, and contain less silicon than the above figures.

*The Length of Springs.*—The longer and more horizontal the spring the easier will be its action. The number and thickness of the plates will vary according to the load and strength of spring required. It is therefore quite as important to know the load per axle as it is for the pneumatic tyres, but careful calculations are not always entered into, and the type of spring used is often the result of trial and error. With a horse vehicle the carriage builder knows within a very little the amount which has to be carried by each spring, but in the case of a car, although the spring may have been designed for a particular body, it does not follow that this will be mounted, and dissatisfaction does occur owing to the purchaser not realizing these conditions. As pointed out previously, springs are used in conjunction, so as to get a good length of spring without detracting from the compactness of the chassis. The cross spring requires a stout stay to connect its centre with the hind cross member of the frame.

*Considerations as to Strength.*—The strength of a spring varies directly as the breadth of its plates, so that one with plates $1\frac{1}{2}$ ins. wide has half the strength of one with plates 3 ins. wide, also it is

determined by the thickness of the plates, the strength being increased as the square of the thickness, so that one $\frac{3}{8}$ in. thick is four times as strong as one $\frac{3}{16}$ in. thick. From this it will be seen that in increasing the stoutness of the chassis suspension, we have a choice between increasing the width and the thickness of the plates, the gauge being the more powerful factor. There is yet another way of adding to the stiffness, for the strength of a spring also varies inversely as its length, and directly as the number of plates, so that a spring 4 ft. long with six plates is of the same strength as one 2 ft. long with twelve plates, and one 3 ft. long with five plates is half as strong as a spring of the same length with ten plates, the plates being of the same gauge and width throughout in the instances mentioned.

The most important plate of the spring is the back one, which first receives the weight, and is on top of a side spring, and at the bottom of the top half of an elliptic spring, or the elbow portion of a $\frac{3}{4}$ elliptic spring. This plate has the eyes at the end of it, which receive the bolts by means of which the spring is swung on the chassis in the front, and to the shackle at the rear. The fact that the eyes are welded on decides in some measure the analysis of the steel used, unless the back plate is made of a special material. The next plate is thinned at the ends, so that it may be wound round the eyes of the spring; the next one usually is tapered so as just to touch the spring eye at its extremities, while the remaining plates are cut off in gradually decreasing lengths until the short plate is reached. The plates are fitted so that they touch the next one at the ends first, before the spring is put together, which method ensures their contact along their whole length, more so than if the whole series of plates were got out from radii having the same centre. Apart from mere ability to resist fracture, the spring has to be designed with a view to its proper deflection without taking a permanent set, or alteration in shape, which suggests that if the spring is over-loaded it will not return to its original shape, in which state it cannot perform its functions properly. One of the common symptoms of an abused spring is the opening up of the plates, which having been strained do not return and lie along the neighbouring ones.

The deflection of a spring varies in direct proportion to the load,

the square of its length, and inversely as its thickness, therefore a 2 ft. spring deflects an inch under a certain load, a 3 ft. spring will deflect $\frac{3 \times 3}{2 \times 2} = 2\frac{1}{4}$ ins. under the same load if the springs in question are of the same thickness. If, however, a spring is $1\frac{1}{2}$ in. thick, and another 3 ins. thick, then the deflection of the thicker spring will be half that of the thinner one. The remaining consideration is simply that if two similar springs have to sustain one and two cwts. respectively, the one under the heavier load will deflect double that of the other.

Closely bound up with the power of a spring to deflect is its ability to spring back to its former position, that is its resilience, which enables it to absorb the vibrations and shocks encountered. This quality is, of course, first determined by the grade of steel used, and secondly by the weight of the spring, so that if the weight is doubled the shock-absorbing power is doubled also. The laminated construction of the spring, setting up friction, also assists the resilience. The formula on which calculations are based is that of D. K. Clark for locomotive springs, which is as follows:—

$$W = \frac{fbt^2n}{L}$$

Where—

W = working load in tons.
$b$ = breadth of plates in inches.
$t$ = thickness of each plate in inches.
$n$ = number of plates.
$f$ = maximum stress in tons.
L = length of spring between centres of eyes in inches.

The constant $f$ is reckoned by various authorities between 11 and 15. Taking the mean of 13, the above formula may then be worked out either to find the number or thickness of plates, the length, and so on. This allowance for safety may be recognized as sufficient if high-class vanadium spring steel is taken as the material to be used.

If the working load on a spring is $\frac{1}{3}$ tons, and it is convenient to arrange for a 39 ins. spring, 2 ins. wide and with eight plates,

then their proper thickness can be ascertained by first working out the value of $t$ in the equation given, and then substituting the values given.

$$W = \frac{fbt^2n}{L} \quad \therefore WL = fbt^2n$$

$$t^2 = \frac{WL}{fbn} \quad \therefore t = \sqrt{\frac{WL}{fbn}}$$

$$\frac{WL}{fbn} = \frac{1 \times 39}{3 \times 13 \times 2 \times 8} = \frac{1}{16}$$

$$\therefore t = \sqrt{\frac{1}{16}} = \frac{1}{4}$$

Or to take another example, what load will a spring 36 ins. long, $2\frac{1}{4}$ ins. wide, 6 plates $\frac{9}{32}$ ins. thick, sustain with safety?

$$W = \frac{fbt^2n}{L} \qquad W = \frac{13 \times 9 \times 81 \times 6}{4 \times 32 \times 32 \times 36}$$

$$\frac{13 \times 9 \times 81 \times 6}{4 \times 32 \times 32 \times 36} = \frac{3159}{8192} \text{ tons} = 7 \text{ cwt. } 2 \text{ qrs. } 23\tfrac{3}{4} \text{ lbs.}$$

*Manufacture of Springs.*—Few vehicle springs are made throughout by hand now-a-days, although a smith who can make a spring is of considerable service in a shop where repairs are carried out. The back plate usually receives attention first, and it is generally the thickest as well as the longest plate used. In cutting the plates to length, allowance must be made for the length of the plate on the curve, for the long plate the curl round the eye and with the other leaves the amount which will be added if they are drawn out at the ends. Sometimes the eyes are welded on, in any case care must be taken to see that the bolt holes are square with the length of the plate.

In cutting the remaining plates to length the allowance made for drawing out the end is usually $1\frac{3}{4}$ ins., and 2 ins. for the short plate, which requires to be a little thinner at the ends in order to give it a sufficient amount of elasticity to compensate for its shortness. If the several plates are drawn down to a gradual taper the strength of the spring, it is claimed, is uniformly increased from end to centre, whereas if the ends be cut off sharply, the spring would tend to be jerky and irregular in

action owing to the thicker parts intercepting at every few inches. Some spring designers advocate simply pointing the ends without decreasing the thickness.

Drawing, or thinning the plates at the ends, is usually done by a machine which has a top concentric roll and a bottom eccentric one, so that there is a space between the rolls at one position when the plate can be inserted, while the further revolution of the eccentric roll bears on the plate and tapers it. Spring plates are often sheared to length, cut to shape at the ends, and provided with nibs and slits all in the same machine. In bending the back plate is first held to a template by two or more pairs of tongs, and each succeeding plate is fitted so that it touches at the ends with a clearance of about $\frac{3}{8}$ in. in the centre for reasons already mentioned.

The nibs and slits are provided so that the plates shall work in line over one another, and the slits must be long enough to allow of the horizontal movement of the plates. In forming these holes and projections great care is necessary, as flaws may easily be started, and the drawn-out end of the plate is a more suitable position than near the centre, as it is more elastic. In an elliptic or three-quarter elliptic spring, however, it is usual to hide one slot by the plate above, so as to be less unsightly and assist in keeping out the wet, so far as the upper portion of the spring is concerned. The centre rivet hole should be drilled so as to guard against the dangers attendant on punching.

*Hardening and Tempering.*—Each spring plate has its edges ground, and the nibs and slits finished off by filing. It is then ready for hardening, which is carried out by plunging the plates into either cold water or oil, after which they are let down or tempered by partially re-heating to a dull red. The temperature at which the steel is plunged is usually in the neighbourhood of 1425° F. From tests made it would appear that plunging in water has the effect of raising the elastic limit more than using oil for this purpose, as it is not so good a conductor of heat, but a more important consideration is the heat used in the subsequent tempering. The higher the temper is drawn, the lower the elastic limit falls, a good average temperature being 750° F. The heat treatment of steel is a delicate operation, and requires

considerable accuracy if uniform and reliable results are to be obtained.

When hardened the steel is very brittle, and the subsequent re-heating has the effect of making the steel softer and more elastic. Different degrees of heat, which are associated with varying colours exhibited by the heated metal, are required for various articles. In the case of a surgical knife, little of the brittleness will be removed in order to ensure a keen edge, while a saw will require to be softer, and so on until we come to springs, where resilience and not a cutting edge is required.

The final process consists in testing the spring, and it is subjected to a far greater load and deflection than it would meet with in actual practice.

*Spring Dimensions.*—In deciding the dimensions of the springs there are several points to be considered. The position of the point of attachment will affect the centre of gravity of the car, while the stability will also be determined by the width over the springs. Not only should the maximum load be known, but the disposal of it. In ascertaining the load which has to be carried, the weight of the springs and wheels and all parts directly connected to the axle must be deducted. This is the unsprung weight, and when there is a gear box as well as a differential gear case supported on the hind axle, this is claimed by the supporters of the chain driven car to be a disadvantage, but so far no great difference in the riding comfort of chain and cardan driven types of cars has been yet proclaimed.

A large landaulette with pressure fed carburretor, which at times will have the head open, and is also provided with a luggage carrier at the rear, will have more weight on the hind springs than a short side entrance phaeton, which has its petrol tank under the driving seat and no luggage carrier. Although two cars may have equally strong springs, yet the one which only carries a full load on rare occasions, will require more deflecting power in the hind springs. The load is generally more or less constant on the front springs, therefore they may be shorter and stiffer than the hind ones. Speed and horsepower should also control the design of the springs, likewise the general character of the roads which will be traversed.

The following tables of sizes will be found useful in ascertaining approximately the lengths required, once the load has been ascertained.

| Weight of complete car (no passengers). | Length in inches. | | Width of leaves in inches. | | Camber (centre of eyes to main plate) in inches. | | Number of plates. | |
|---|---|---|---|---|---|---|---|---|
| | Front. | Hind. | Front. | Hind. | Front. | Hind. | Front. | Hind. |
| 16 cwt. | 36 | 42 | $1\frac{3}{4}$ | $1\frac{3}{4}$ | 2 | 2 | 5 | 5 |
| 18 ,, | 36 | 44 | $1\frac{3}{4}$ | 2 | 2 | 2 | 5 | 5 |
| 20 ,, | 38 | 46 | 2 | 2 | $2\frac{1}{4}$ | 2 | 5 | 5 |
| 22 ,, | 38 | 48 | 2 | 2 | $2\frac{1}{4}$ | 2 | 5 | 6 |
| 24 ,, | 38 | 50 | 2 | $2\frac{1}{4}$ | $2\frac{1}{4}$ | $2\frac{1}{4}$ | 5 | 6 |
| 26 ,, | 40 | 52 | 2 | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{1}{4}$ | 5 | 6 |
| 28 ,, | 40 | 54 | $2\frac{1}{4}$ | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{1}{4}$ | 6 | 6 |
| 30 ,, | 40 | 56 | $2\frac{1}{4}$ | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{1}{4}$ | 6 | 7 |
| 32 ,, | 40 | 56 | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{3}{4}$ | $2\frac{1}{4}$ | 6 | 7 |
| 34 ,, | 42 | 58 | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{3}{4}$ | $2\frac{1}{2}$ | 6 | 7 |
| 36 ,, | 42 | 58 | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{3}{4}$ | $2\frac{1}{2}$ | 6 | 7 |
| 40 ,, | 42 | 58 | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{3}{4}$ | $2\frac{1}{2}$ | 6 | 7 |

When two side and a cross spring are used in conjunction at the rear, the side springs may be reckoned at the same length as given above, the cross spring averaging 40 ins. in most cases.

The length of the elbow portion of a three-quarter elliptic spring is about three-fifths of the lower part.

The following gauges are used in describing the thickness of spring plates:

| Gauge. | Nearest 64ths of an inch. |
|---|---|
| | $\frac{23}{64}$ |
| 1 | $\frac{19}{64}$ |
| 2 | $\frac{18}{64}$ |
| 3 | $\frac{17}{64}$ |
| 4 | $\frac{15}{64}$ |
| 5 | $\frac{14}{64}$ |
| 6 | $\frac{13}{64}$ |

The back plate is usually made of a stouter gauge than the rest of the plates, and sometimes the short plate is the same gauge as the back plate. As there is movement between the plates of a laminated spring, and at the shackles, proper lubrication is necessary for efficient working, and also all tendency to rust must be prevented. Before putting a spring together it is usual to either

paint the spring with a coat of smudge, or to brush over a mixture of tallow and graphite. The modern motor car spring is provided with grease caps to all the shackle and other bolts, but lubrication may also be carried out by using a special pattern such as the Nelson-Blakely spring, which has an enclosed shackle at each end and a central hollow bolt through which the oil travels to a groove provided in each plate. The enclosing of the shackles is recommended in all cases where ordinary types of springs are used, and recourse may be had to the use of a leather boot, such as is adopted with the steering, and universal joints of the shaft drive.

# CHAPTER XXVII

## *CHASSIS ACCESSORIES*

The most important accessories which are directly concerned with the chassis are hooters and other warning devices, speedometers, odometers, gauges and other measuring instruments, while a leading item amongst the tool equipment is the jack for raising any wheel from the ground for tyre repairing and manipulation.

*Hooters.*—Horns or hooters of some description are a legal necessity as well as a safeguard in preventing accidents. The usual type with a bell mouth and neck of various shapes is provided with a metal reed, which vibrates under the influence of the rush of air occasioned by the compression of the rubber bulb. The mouth of the horn should be protected from dust by a gauze cover, and the fixing should allow of the sound being well projected forward. Attachment should interfere as little as possible with the steering, and any flexible tube which is used should be kept free from sharp bends. A good position for the horn is the centre of the dashboard, especially when it can be wholly or partially let into the scuttle dash. The horn should be fixed so that nothing comes in front of it, therefore it should not be placed behind the front wing, for instance, but on top of it. Horns may also be actuated by a foot pedal working a plunger in an air cylinder.

*Electric Horns.*—The disadvantage of the ordinary hooter is the liability of the rubber bulb to fracture, and the length of tubing necessary with some positions adopted. It is not always a simple matter to blow the horn successfully in a moment of danger, and for this reason the neat electric pattern appeals to many. With this type there is only a button to push and the response is instantaneous, and many have great penetrating powers. Usually a small electric motor is run vertically, while to the upper end of a spindle

is mounted a toothed wheel which as it revolves hits against a projection set in the centre of a steel diaphragm, which is placed right across the inner end of the mouth of the horn. The motor is connected up by flexible wiring to a six or eight-volt battery, or other generative system, and when the circuit is closed by pressing the button (usually placed on the steering wheel), the motor is made to revolve at about 3,000 revolutions per minute, and as there are ten projections on the toothed wheel, the diaphragm is struck some 30,000 times a minute. The sound may be varied in intensity by adjusting the distance between the toothed wheel and the anvil. Other types of electric horns may have plain diaphragms with strikers flying out to hit them, actuated by centrifugal force.

*Exhaust Whistles.*—The exhaust gases are often utilized to send a forcible current through a valve so as to make a warning sound, and of late, notes of a very pleasing and well modulated tone have been produced by this method. Normally the exhaust passes into the silencer, but the depression by the driver of a small pedal connected by a wire cable closes either wholly or partially the way into the silencer, and diverts the rest of the gas into the note-producing apparatus. A leading pattern consists of a polished brass cylinder divided into three portions, each compartment producing a separate note, and arranged to sound in harmony. Multiple-note horns may also be controlled by a tiny key-board, which allows the driver to use any or all of the notes desired. The notes are governed in another variety by a bulb working a rachet, and a valve may be provided so that a tremulous effect is obtained.

The exhaust cut out is simply a valve or shutter which is closed in the exhaust pipe in front of the silencer so that the noise of the explosions in the cylinders is transmitted in a modified form to the open air. As a rule, the valve is worked by a pedal working in a rack attached to a wire cable.

*Syrens.*—The syren consists of a rotating fan or paddle wheel moving in a chamber provided with slots, to which is attached a bell-mouthed horn, similar in shape to the bulb-operated pattern, only somewhat larger. The fan wheel spindle is connected by a flexible shaft, or pulley and belt, to a small friction wheel or roller, which is held in position against the flywheel of the motor by a small bracket. The ratio of the flywheel circumference to that of the friction wheel

is, say, as eighteen to one, so that the speed of the fan wheel may easily be as high as 18,000 revolutions per minute. A small pedal and wire cable brings the roller to bear against the flywheel, and as it picks up speed so a more or less piercing shriek is produced. In some districts abroad, it is understood that the use of the syren is forbidden, owing to its objectionable nature, while the musical exhaust horn, as described above, is reserved in Germany for the Royal pleasure. The syren may also be rotated by electrical means.

*Foot Bells.*—A gong is sometimes fitted under the floor of commercial and electric vehicles, which is operated by a pedal in connection with one or a pair of clappers.

*Speedometers.*—The speedometer is a useful accessory as well as adding considerably to the pleasure of driving, since the number of miles run are usually recorded as well as the rate one is travelling. Much ingenuity is displayed in the construction of the delicate mechanism which moves the index finger on the dial, and broadly the principles of working adopted may be divided into magnetic and centrifugal action. With the magnetic system a horse shoe or other shaped permanent magnet is mounted vertically on a spindle connected by gearing to the flexible shaft, which may be driven from a toothed ring attached to the inside of the off-side front road wheel hub plate, against which a spur wheel is kept in mesh.

The drive is sometimes arranged by having a small belt drive taken off the cardan shaft to a small wheel specially mounted on a bracket inside the frame side member. The magnet as it revolves exerts a pull on a metal disc, the disc being directly attached to the index finger. Acting in the opposite direction to the pull on the disc is a hair spring fastened at one end to a stationary keeper, and the balance of these forces results in the pointer indicating on a graduated dial the speed in miles per hour. It follows therefore that there is no positive connection between the pointer and the driving mechanism, but merely the revolution of the metal disc by means of magnetic force acting against a fine coiled spring. The case and other parts of the speedometer are of brass, or other non-magnetic material, so that the influences set up by the magnets are confined to the disc.

In the Cowey speed indicator, a balance wheel is set in motion by the front wheel drive against a small spring, which is connected to the balance wheel by a small chain, in such a manner that it tends to draw continuously the balance wheel towards the zero position, while the drive gives a series of intermittent impulses to the wheel which acts upon it in the opposite direction, so that the greater the speed of the balance wheel, the more it succeeds in overcoming the retarding action of the spring. The Smith speedometer has a small centrally jointed governor to which is fastened three weights turning horizontally on a spindle. As these weights fly out, so they contract the central axes of the governor, and in so doing act on a series of three springs of different strengths. The most delicate spring is acted on first, thus ensuring that the speedometer shall respond at low speeds, while the inner end of the governor pulls on a small worm drive, which is connected to the index figure mechanism.

Some centrifugal speedometers are fitted with steel balls, which, as the speed increases, move upwards in a special track and raise a spring which controls the movement of a rack and pinion. Balls as they are whirled may also turn a cup on the edge of which is a finger which comes in contact with a lever connected to the pointer moving mechanism. A very simple type is the instrument which utilizes the principle of the position taken up by a liquid when it is contained in a vessel revolving on its vertical axis. Under these conditions, the liquid falls in the centre and rises at the side.

Speedometers are slightly affected by the weather, but the error is of little moment unless the car is travelling above the legal limit. The majority of instruments read accurately at about 80° F., so that on most days the pointer will be a little fast, perhaps a quarter to a half mile at the most. At sixty miles per hour, on a very cold day, the record may be some six miles fast, while it is necessary for the temperature to be well above 100° F., and the car travelling over forty miles per hour, for there to be an appreciable error.

The odometer or distance recorder usually allows of the mileage being totalled throughout the year as well as on each trip, it being possible to reset this to zero after the completion of the journey. The annual mileage maximum may run up to 100,000. If the zero point is required again before reaching this total it is advisable

to send the instrument to the makers. Any flexible shaft used, as with horns, should be as free from sharp bends as possible.

A tachometer is an instrument for counting the revolutions per minute of the engine crank shaft.

Speedometers are also provided with a maximum speed hand, which stays at the position indicating the greatest number of miles per hour attained since the hand was last released to zero. The driving of measuring instruments from the road wheels necessitates that the device should tally exactly with the front wheel circumference. This should be obtained by chalking a mark on the tyre, and at its contact with the ground, and running the wheel along a smooth place until the tyre mark is again at the lowest position. It has been found that owing to skidding the driving wheels are not a proper place to fit up the drive, so that any device connected to the transmission system is liable to suffer from the same cause. This fact has been clearly demonstrated with the use of taximeters, and now it is enforced that they shall be connected up to the steering wheels.

*Jacks.*—One of the weighty tools which have to be carried on the car is the jack. This should have a broad base, be quickly adjustable, strong, and with all the working parts hardened to stand wear. The common type consists of a hollow pedestal in which is a short shaft connected at its top with bevel gearing, so that when the detachable handle is inserted and turned, the revolving shaft provided with a worm rises in the pedestal. More powerful types suitable for garage work have a longer and fixed handle which may work in conjunction with a rachet. Others work by foot pressure, while rim jacks are quickly operated and useful when attaching a Stepney wheel. A jack may also be specially made to suit a certain car having a pair of long handles attached to an axle running on a pair of castors. A pair of short arms are provided with suitable depressions which grasp the car axle when placed underneath, and on depressing the long handles an easy leverage is obtained, and the car is thereby quickly lifted with a minimum of energy.

# CHAPTER XXVIII

## *THE PRESERVATION OF THE CAR*

*Preservation means Economy and Absence of Breakdown.*—The proper care of a car means economy in upkeep, and even if expense is of little consideration, careless operation may easily lead to breakdowns on the road, which will be the source of much trouble and inconvenience, so that a right appreciation of how a car should be cared for is essential to the enjoyment of motoring.

The man of a systematic temperament takes a natural delight in going through a certain routine every time he takes his car out for a journey, but there are others, even paid chauffeurs, who need forcible reminders before they realize that a road machine needs periodical attention, in order to give satisfaction.

*Systematic and Periodical Attention.*—The successful management of the car depends on the realization as to the intervals which should elapse between each filling of the tanks, the inspection of various parts of the car, and so on.

If a mileage recorder is carried, and the motorist knows the miles per gallon his car averages, together with the capacity of the petrol tank, a rough calculation will soon show him if he can get home without replenishment. A careful motorist will prefer a gauge of some sort fitted, and will carry a spare tin, to be used only in emergencies.

*The Preliminaries of every Journey.*—It should be made a rule always to fill the tank on setting out, no matter what amount of fuel may be remaining. In like manner the start from home should be with tyres pumped to their right pressure, a full radiator, and the oil reservoir, whatever its type, should be filled up to the correct level, and if a particular brand is desirable for a particular engine, and it is unlikely that a tin can be purchased *en route* if the

run is to be a long one, then a spare supply will give confidence, even if not actually required.

*Lubrication and Greasing most Important.*—The man of natural mechanical inclinations goes round with his oil can as a matter of habit, but this is not always the case with the man who will pass through a squeaking gate at home, and struggle with refractory bolts, without itching at once for a bit of grease. The lubrication systems on various cars differ in detail, and are summed up elsewhere; also it is unnecessary to buy a car whose maker does not supply ample information, both descriptive and illustrative, as to every point in the car's anatomy which requires grease and oil. The amount of lubrication to be given to any part depends on the amount of work performed per car mile, and the nature of the bearing. Lubrication must be well provided for always in the main bearings of the engine, and such parts as all steering connections, and the clutch, while attention should be given every hundred miles to the spring greasers, for the movement here is incessant, though the radius of action is small. Those who are cyclists will require no reminding that the tyres should be inspected after each day's run, and part of the preparation for a journey consists in testing the tightness of the various bolts and nuts.

Lubrication of all bearings is not called for every day, but the greater the day's mileage so a shorter period will elapse before this becomes necessary. If a daily average of thirty-five miles is covered for a week, then all minor bearings should receive attention at the week end, or, say, once in every two hundred and fifty miles, while those of the engine, the steering, and springs, after every day's run. Considering the many places where oiling has to be done and grease caps given a turn, apart from following out the chart at hand, a certain order should be striven after, so that no bearing is omitted. This may be done by working gradually round the engine from one side to the other, and so on round the chassis, doing those parts under the floor boards, say, after all has been done forward of the dashboard. Such parts as ignition and throttle levers and the magneto bearings, bonnet catches, door and wind screen's hinges, will only need a drop or two of oil.

*Draining Out and Flushing.*—Although a daily replenishment of oil has been given to the engine, the whole should be drained out

after every two thousand miles, and the whole flushed out with a half-gallon of paraffin, any gauze belonging to the oil filters thoroughly cleaned, the engine run for a few moments, drained out, and then replenished with oil. In most cars the gear box is filled with grease; this will now be entirely removed, the gear box washed out with paraffin and replenished with lubricant. It is a good plan to dissolve some of the old grease in a glass with petrol, and note if any metallic sediment is formed; if so, the wear of the gears should be noted, and great care taken to remove all dirt and other matter liable to set up abrasion.

Should the gear box be oil fed, then this will receive similar daily and periodical attention as the engine. Washing out and replenishment will also proceed at the universal joints, differential case, back axle, and all grease caps.

A new car requires more generous lubrication than one which has been running a month or two, but lubrication should be carried out with care and cleanliness, so that dirt is not attracted unduly to oily surfaces, while bearings which are grease-lubricated require, of course, less attention than those which are oil fed.

Daily lubrication may include attention to the rocker arm bearings of overhead valves, or some important bearing on the propeller shaft; in fact, each car must be a law unto itself, and the wise motorist will know his oiling chart thoroughly.

*Attention given to Radiator and Spring Plates.*—When draining out the engine the water should also be emptied from the radiator, and the water jackets inspected for fur, and in the majority of cases a good flushing out with soda water will be advisable. The car may also be jacked up, thereby relieving most of the pressure between the spring plates, and some grease inserted. Some makers advise emptying the petrol tank, so that any water present in the bottom may be removed, and also washing out the carburettor thoroughly.

Leaks should be looked for daily in all parts of the petrol, oil, and water systems, and a precaution not always indulged in is to have a preliminary canter with the car, merely for the purpose of testing both hand and foot brakes, which will, at the same time, test the proper working of the steering gear.

Periodical adjustment is necessary to the fan belt and brake

rods, say, once a month, while more important bearings will probably be done under professional guidance at the yearly overhaul.

*Ignition Precautions.*—Under ordinary mileage conditions, accumulators will be recharged once a month; dissatisfaction with this part of the equipment is seldom through too much attention in this direction. The wiring should be constantly inspected, whatever the system used, and particular attention paid to the fastenings at the terminals, to see that they are in good order. Platinum points should not be filed periodically, but only if they are found to require it. All parts of the ignition, except moving parts, should be dry and clean, and the mechanism of the modern magneto can usually be left severely alone, except for an occasional drip of oil, and cleaning of the points of the contact breaker. The porcelains of the sparking plugs should be free from cracks; if any develop, a new one must be screwed in, while some motorists will take them out occasionally to see that the points are clean; but this inspection usually occurs when the engine has been misfiring.

Thorough insulation of the wiring is highly important in all parts of the high-tension circuit between the magneto and plugs.

*Valve Grinding and Care of the Clutch.*—Valve grinding, especially the exhaust ones, is recommended once a month, the operation being performed with a paste of emery and paraffin, or special tools may be utilized, while proper response of the valves to their tappets is ensured by their clearance being always about the thickness of a visiting card. Castor oil, and not resin, should be used on a slipping leather clutch, and sometimes a slight adjustment of the spring may be necessary, while a fierce one may be assisted with a little paraffin. Plate clutches require a special lubricant. Re-leathering should only occasionally be required, say, once in 20,000 miles. Further details of the car's management will be furnished by the motor manufacturer, either in the catalogue or a special instruction book, those supplied by the Daimler, Argyll, Wolseley, and Napier firms being excellent examples, while American manufacturers are also fully alive to the advantage gained by the publication of these handbooks.

*The Care of the Bodywork.*—As regards the bodywork, this does not always receive the attention it deserves. The man who owns a car of small or medium power, and looks after the well-being of the

complete vehicle himself, is likely to begrudge the attention necessary to keep the varnished panelling bright, and the interior upholstery clean, while much has been said on the subject of the labour entailed in keeping the metal parts, such as lamps, beadings, handles, and step edging, in a cleanly condition.

Some motorists have endeavoured to compromise matters by having a body finished with a flat surface, that is, unvarnished, while much of the usual plating work is substituted by having them japanned or finished with a gun-metal effect.

A car gets dirtier quicker than a carriage, because of the greater mileage and speed. There has yet to be discovered a varnish of greater durability to withstand the rougher usage.

Trimmings should be dispensed with where possible in touring cars, and cocoanut-fibre mats on the floor are preferable to wool rugs and carpets. The practice is daily growing in favour of using small fibre mats, either strapped on or let into the step.

*The Motor House.*—The motor house must be dry and free from ammonia fumes such as will be always present in a stable; therefore, if horses are kept, there should be no direct communication. As ammonia is used sometimes for removing paint and varnish at the motor body builder's, it will be needless to say more on this subject. The motor house should be kept clean and free from dust, and no direct rays of sunlight should be allowed to play on the panels for any length of time, a remark which also applies when the car is on the road. The car should stand with a fair gangway all round, not only for convenience of inspection, but because the proximity of brick walls generally means a continual, although slight, emanation of dampness. The motor house should be swept once a week, after the car has been drawn out, and much labour will be saved if the whole vehicle is enveloped in a light cover made to approximately fit the outlines of the car, and just clearing the ground. Tools, accessories, and spare parts should be installed in cupboards rather than on shelves. A concrete or hard wood floor is recommended, and all plastering should be in good repair. Top skylights are liable to be the source of much dust and dirt, as well as leakage.

Mention has already been made in the chapter on painting as to the use of a newly varnished car. The first home-coming from the factory should be followed by a wash down in clean cold water,

and frequent washings are more necessary with a new than an older car, as each application of water hardens the varnish.

*Washing a Varnished Panel.*—The body should always be washed after the day's run, however short and whatever the weather. Mud which has dried on should be gently soaked off with a liberal application of water under gentle pressure assisted with a sponge free from grit. Washing should be done in a shady place, on hard ground, and, if the weather is frosty, the slightly warmed motor house will be desirable. Wheels are cleaned by raising them with the jack or setter, and the use of the spoke brush is not recommended if the varnish is to be kept as bright as possible, as it tempts the operator to use more friction than is desirable. Wiping off is done with soft chamois leathers.

In washing an open car, all cushions, carpets, and so on, will be removed, while care must be taken not to wet the exposed portions of the trimming. In a closed body all lights will be raised. The sponge should be squeezed, not rubbed over the panels. This operation should be confined to the use of the leather when all mud, and therefore abrasive mediums, have been removed. A good system is to wash the roof first, then the leather work (if any), afterwards proceeding with the body and wings, and lastly the chassis and wheels, the idea being that no dirty water can run on to a freshly cleaned surface from above.

*Cleaning the Metal Parts.*—A gentleman's brougham has usually but few bright parts, and, in many cases, the plating is confined to the door handles, axle caps, and beading on the border of the driving seat; but in a car the list will often include five lamps, four door handles, two top levers, bonnet details, a pair of ascending handles, dash and elbow beading, wind-screen stanchions and fittings, luggage rail scrolls, step edging, numerous dashboard fittings, a hooter, and axle caps. All this brilliancy is merely the dictates of fashion, and can easily be modified if the motorist cares to select full or partly japanned lamps, and have various body details painted or stove enamelled.

There are many polishing pastes on the market, but the brilliancy of the several parts may be maintained if only the chauffeur will give them his daily attention with a woollen rag and a little elbow grease. Once a cleaning compound is used, it must be kept

up. If a powder or paste is used, it must be finely ground and free from acid. Whitening is recommended for nickel and silver mountings, while many praise highly the use of paraffin for the glass, but this should never be used in the body washing water, although it may be used on greasy parts of the chassis and wheels.

*The Care of Cloth and Leather Trimmings.*—New leather should simply be washed. Neatsfoot oil may be used with advantage when the leather begins to harden, which should be allowed time to soak in and then wiped off, the operation being repeated weekly.

Cape cart hoods and the leather heads of landaulettes should be kept fully extended when the car is standing in the motor house. Grease stains on the paintwork should first be attacked with a good quality soap and cold water, while any obstinate stains may be treated with a gentle application of boiled linseed oil and wadding, and afterwards wiped off.

A body is trimmed so that, if it is a cloth lining, the nap brushes from top to bottom and from back to front. This should be remembered when brushing out the lining after the cushions have been removed.

Moth-eaten trimmings are prevented by giving the car periodical ventilation and exposure to light, if it is to be shut up for an extended period, also thorough brushing, so as to disperse all eggs, say, once a month. An extra precaution is to keep a quantity of camphor dissolved in turpentine in the interior.

Morocco and other leather linings may be cleaned with a chamois leather or soft rag. Morocco is water dyed, so that it must not be sponged.

Now and then a coloured varnish paint may be applied to the wheel rims, and, if there are any step treads, a little black paint may be indulged in occasionally. Rubber matting should never be painted, but brushed over with chalk. If the shabby appearance is disliked, recourse may be had to an aluminium matting.

The preservation of the underparts of the mechanism will rely a great deal on the design of the undershield. This, in conjunction with effective side guards to the wings and step, will save a lot of labour. When inspection is necessary, the undershield should be easily detachable, each portion being capable of detachment without

interfering with the others. When the engine and gear box is made as a unit, this simplifies matters to a great extent.

There are various specially made washing appliances on the market, which consist of hose attached to self-saturating sponges and brushes with means whereby the supply can be easily controlled.

*Removing Spots.*—Tar spots are removed by a gentle application of naphtha and cotton wool, wiped off as soon as the spots soften—a slight damage to the varnished surface is almost inevitable.

Various polishing creams should be tried with caution, and on the whole should be avoided.

Rain spots, which are very liable to form on the heated portions of a bonnet, may be almost obliterated with boiled linseed oil and a soft rag.

Unvarnished paintwork may be cleaned with paraffin. Close plating should be indulged in, if it can be afforded, as the extra expense is justified by the longer wear over electro plating.

The vacuum cleaner is useful for removing the greater part of dust from linings, especially in awkward corners and crevices.

A moderate yet thorough application of benzene will clean a dirty lining, applied with a stiff brush, but it should be done in the daytime away from all lights, and smoking should not be indulged in.

*General Precautions.*—The position of the exhaust outlet often accounts for a blistered back panel. It is a good plan to fit a deflecting plate so that the hot gases are dispersed as widely as possible just behind the car.

Aluminium surfaces should be cleaned with a turpentine rag.

Lamps may be kept in fitted bags of soft material during the daytime, and should always be wrapped up when not in use, in the motor-house lockers.

Detachable wheels, rims, and flanges should be taken off once a fortnight and lubricated, as well as those carried on the car.

Loose floor boards should always be rectified by the insertion of new ones, or packing at the edges, as much dust will enter the body in this way.

Cape cart hoods must not be cleaned with petrol, or other solvent of the inner rubber layer or outer dressing. Soap and water is the best medium.

Polished woodwork should be dusted and rubbed over with a linseed oil rag, and afterwards wiped off.

The back of driving seats in open cars should have a protecting shield, especially at the bottom where it may be kicked. This shield may be of greater utility if it forms a pocket for storing small articles.

The doors of a car should always fit tightly when closed; they should never be slammed or leant upon. A slight rattle in door or glass frames should be immediately rectified by any adjustable device present or by calling at the coachbuilder's.

The hood of a landaulette should be systematically lowered by first dropping the curtains from horizontal to vertical, unfastening the head locks or catches, and striking the joints. The back light should lay on the back squab and not on the panel, and it may be necessary to tuck in the leather as the hood is lowered, especially with a new one.

The care of tyres has already been dealt with in the chapter devoted to them.

Advice regarding a car laid by for the winter is seldom now required, as motoring is now practicable at all weathers. The engine and lubrication generally, in this instance, requires extra attention such as would be given after a mileage of 2,000; all petrol and water should be emptied out. The accumulators should be re-charged, the electrolyte emptied out and replaced with clean water. This advice may vary slightly according to the type of accumulators used.

Tyres are best removed, wrapped up and stowed away in a dry dark place, while the axles will be supported on strong low trestles. The body should be periodically ventilated and brushed out.

The bodywork of a car should be touched up and varnished at least annually.

# CHAPTER XXIX

## *MOTORING AND ITS COST*

*The Price of Chassis.*—Some attention has already been given, in Chapter XVIII., to the choice of a chassis. Going into the matter more closely, it will be found that the British market is well supplied with cars to suit a wide range of outlay. One-cylinder chassis, varying from 6 to 9 horse-power, may be had from £115 to £200; two-cylinder chassis, with a horse-power varying from 10 to 20, are available at from £160 to £450; four-cylinder ones, with horse-power from 10 to 120, which are listed as low as £155, run up to £1275; while in the six-cylinder class one finds horse-power rising from 23 up to 90, and the prices asked run from £350 to £1700.

Roughly speaking, price depends first on horse-power, and the extra smoothness of running gained by having a multiplicity of cylinders has to be paid for, because of the extra number of parts entailed. As a general rule, two chassis of the same horse-power, having the same number of cylinders, but of different price, will mean that the lower-priced one has less speeds provided for in the gear box, accumulator ignition instead of a magneto ignition, or a double system, the wheel-base is shorter, the track is narrower, small tyres are used, and in a few cases a chain-drive will be present, and a friction transmission instead of the usual gear box. Where the difference is not readily apparent, a greater price for the same horse-power will then mean that the chassis is provided with several refinements not mounted on the cheaper one, the material is better, likewise the finish, and it may be that the specification includes more accessories, and a more generous kit of tools and spares than that present in the other chassis.

Coming to averages, one must be prepared to spend £150 on a one-cylinder chassis (although in most British instances this cannot be reckoned as a separate outlay, as the complete car with body has

to be bought), £250 on a two-cylinder chassis, £300 on a four-cylinder one, if the horse-power required is not greater than 15, while for a powerful car at least double that amount must be expended before the body is thought of. A six-cylinder chassis of say 30 horse-power will cost £600.

*The Price of the Body.*—The next big item is the cost of the body. This will vary quite as much as the chassis, and, as a rule, one is tempted to spend money on the body in proportion to the price of the chassis.

A two-seated body for a single-cylinder chassis, with cape hood and glass screen, will cost about £55 to £75. A similar body for a two-cylinder chassis, somewhat longer, and provided with a folding seat at the rear, will run from £75 to £115, and a body of this type fitted to a four-cylinder chassis and designed by a leading firm, may cost even as much as £175.

Side-entrance phaetons, of various kinds, vary greatly in price because there are so many degrees of finish. A small four-seated car may be had as low as £65, and one may continually meet with prices even lower than this, but the quality of such work is not dependable, or else the builder has little idea of the cost. At £65 it is improbable that a cape cart hood and glass screen will be included, so that in order to get good workmanship £100 should be allowed for a small phaeton and up to £160 for the larger variety holding seven persons.

Satisfactory small limousines and landaulettes, finished neatly, may be had for £160, but it is easy to spend another £100 on such a type of body by having it larger and more luxurious in every way.

Cabriolets cost somewhat more than landaulettes, while large enclosed cars run from £300 to £350.

*Extras.*—In purchasing a body or a chassis one should be on the look-out for extras, but this matter is seldom of much consequence if one is paying a good price. When ordering a body one should obtain a full specification of all details included, so that there is no misunderstanding as to whether side curtains to the cape cart hood are included in the price stated, or a luggage rack at the rear, or certain cantines, folding tables, and electric light in a limousine, and so on.

Lamps are nearly always a separate item, but sometimes the dash lamps are given with the chassis. The body price should include the provision and fixing of all lamp irons required. A small car will have some £10 worth of lamps, a set of five lamps on the average car running into £25, while the spare wheel and fittings will cost, say, with tyre, £15, a speedometer, £5, which with other details usually means some £25 worth of additional expenditure on what may be reasonably defined as the complete car, and double that amount on a larger one.

*The Complete Capital Outlay.*—To sum up, one should be willing to spend at least £250, and this sum may be looked upon as a minimum for a small car, while the majority of motorists spend double this amount on the complete car, before the question of maintenance is reckoned. A powerful car, with luxurious appointments, may easily run into four figures.

It is as well to form a definite idea as to what constitutes capital outlay, because accurate and just accounts of the cost of running a car can only be obtained by appreciating this properly. Depreciation should be deduced from capital expenditure, while at the same time capital expenditure should not be confused with the maintenance account.

*Depreciation.*—The capital account will consist of the complete outlay on the new car; if special clothes and wraps are bought for use with the car these items should be added, likewise any special motor house which has to be built. The total expended should be added up, and then divided by a figure which will give a value representing the decrease in value, owing to wear and tear, of the car at the end of the year. This is depreciation, and is a matter on which there is much controversy as to its proper expression. Depreciation can only be accurately ascertained when the car has been disposed of, for then the loss on the transaction is the depreciation value, and this sum spread over the mileage attained during ownership will show how much must be added to the cost of fuel, lubricants, tyres, and other items, to give the cost per mile run. On an average it may be safely assumed that a new car loses 20 per cent. in cash value at the end of the first year of careful running, 15 per cent. for the second and each subsequent year—that is to say, in six years the car would only be worth a few pounds,

unless the progress made in automobile engineering was slower than usual.

*Petrol.*—The cost of petrol, or other fuel, can of course be easily ascertained. The number of miles run per gallon will depend largely on the horse-power and total weight of the car, likewise the care used in driving, the type of roads traversed, and the frequency of stoppages.

As much as 60 miles to the gallon has been accomplished by well-designed single cylinder cars running on good level roads, but 25 to 30 is nearer the average, while large heavy cars consume a gallon of petrol every 10 to 15 miles. Reckoning petrol at 1*s.* 3*d.* per gallon and the run of the average car on a gallon of fuel at $22\frac{1}{2}$ miles, the cost per mile on this item alone is $\frac{2}{3}d.$

*Lubricant.*—Under this heading is placed oil and grease. The amount used on the car, on a thousand mile run, will vary not only according to the size and type of car, and the roads traversed, but also on the judgment shown in lubricating. There are occasions when much waste occurs, and it is quite possible for two cars built on the same model to show bills for lubricant whose totals vary as 4 to 1. A car should not cost more than 10*s.* a 1000 miles for oil and grease. Lubricant then may be estimated at $\frac{1}{8}$ of a penny a mile.

*Tyres.*—The largest item in the running expenses is the tyres, unless the car is a very expensive one, and is subsequently sold at a big reduction, then the depreciation value per mile may even exceed the tyre item. The fairest way to judge the cost of tyres is to keep an entry of all tyre repairs and changes in conjunction with the speedometer reading, so that the miles run per cover and tube can be approximately obtained. The life of tyres is much a matter of luck, especially if the motorist travels on unfrequented routes. On the whole it has been observed that the tyre bill rises rapidly with the horse-power and weight of the car, so that it cannot be too strongly impressed on the man of moderate means, that a small light car not only means small outlay, but small maintenance as well, while at the same time he may enjoy the same delights of speed up to the legal limit, as the owner of a larger car.

Many small cars up to say 10-H.P. are run on a tyre bill of $\frac{1}{2}d.$

a mile, a 15-H.P. car will run into 1*d.*, a 25-H.P. 2*d.*, and beyond that size 3*d.* a mile.

*Repairs and Renewals.*—Many cars are run for many hundreds of miles with but a few shillings expended on mechanical repairs, but this item sooner or later mounts up to a fair sum, especially if the car is continually used, and is liable to be neglected now and then. As an average one may consider the cost under this head, for a small car $\frac{1}{2}d.$ a mile, and for a larger sized car $\frac{3}{4}d.$ a mile. The wear on the gears depends on their quality and not on the size of the car, so that a high-priced car of 50 H.P. need not cost any more on repairs than one of half that horse-power, but naturally if important renewals are necessary, the larger car will require the greater outlay. It may be mentioned here that unlooked-for breakdowns in the first year of ownership of a new car will probably be covered by the maker's guarantee, while all repairs owing to accidental damage may be covered by insurance, although some car owners have saved this expense, and found it economical in the long run, as naturally it must be in many instances, otherwise insurance companies could not exist, let alone prosper. The figures quoted above will include body repairs and renovations.

*Insurance.*—This item which has just been mentioned, varies according to the risk covered, the horse-power of the car, and its value complete with accessories. Policies may be obtained to cover, not only accidental damage to any part of the car, but destruction from fire, theft, damage during transit, and personal injury. The policy should be carefully read before closing with the insurance company, and it should be made plain as to how far the owner is recompensed for small items. Various reductions are allowed if the car is driven only by the assured, if no claim is made, if all claims below a certain sum are borne by the assured, and if more than one policy is effected at a time. A sum of £15 a year will cover a great many risks on a £500 16-H.P. car, which on the basis of a 10,000 mileage per annum works out about $\frac{3}{8}d.$ per mile.

*Wages.*—A small car will probably be run without hired assistance of any kind, although it is possible that money may be spent occasionally in having it cleaned. Large cars, of course, necessitate a chauffeur, and wages run largely according to competence and previous experience. If a boy receives only 7*s.* a week, but lives in,

the value of his meals and lodgings should be added. The wages item may vary from, say £10 up to £250 for a fully-trained man, and on an average one may reckon on £2 a week, so that with a 10,000 annual mileage this item will be over 2*d.* a mile.

*Taxes.*—The registration of the car costing £1, belongs strictly to the capital account, but the driving licence has to be renewed annually, likewise the horse-power tax. The petrol tax is not paid directly, but is included in the price paid, as with spirits and tobacco, while rebates, if allowed, have to be afterwards claimed, a matter which sometimes requires a little persistence.

One may generally ascertain the tax on a certain chassis before purchasing. The figures are: for cars—

| | £ | *s.* | *d.* |
|---|---|---|---|
| Not greater than 6½ h.p. . . . . | 2 | 2 | 0 |
| ,, 12 ,, . . . . . | 3 | 3 | 0 |
| ,, 16 ,, . . . . . | 4 | 4 | 0 |
| ,, 26 ,, . . . . . | 6 | 6 | 0 |
| ,, 33 ,, . . . . . | 8 | 8 | 0 |
| ,, 40 ,, . . . . . | 10 | 10 | 0 |
| ,, 60 ,, . . . . . | 21 | 0 | 0 |
| Exceeding 60 ,, . . . . . | 42 | 0 | 0 |

The driving licence costs 5*s.* a year, a male servant's 15*s.*, and if armorial bearings are used a further £2 2*s.* tax has to be paid. Taxes will average from $\frac{1}{8}d.$ to $\frac{1}{4}d.$ per mile.

*The Cost per Mile Run.*—To sum up the various items of expenditure, it will be found that the cost of running a small car for 5,000 miles is somewhat as follows :—

| | £ | *s.* | *d.* |
|---|---|---|---|
| Initial outlay £250, depreciation at 12½ per cent. . | 31 | 5 | 0 |
| Petrol at $\frac{2}{3}d.$ per mile . . . . . | 13 | 17 | 9 |
| Lubricant (oil and grease) at 10*s.* per 1000 . . . . | 2 | 10 | 0 |
| Tyres at $\frac{1}{2}d.$ per mile . . . . . | 10 | 8 | 4 |
| Repairs and renewals at $\frac{1}{2}d.$ per mile . . . . . | 10 | 8 | 4 |
| Insurance per annum . . . . . | 8 | 0 | 0 |
| Wages per annum . . . . . | 12 | 0 | 0 |
| Taxes per annum . . . . . | 3 | 8 | 0 |
| Interest at 4 per cent. on £250 . . . . . | 10 | 0 | 0 |
| Or about 5*d.* a mile . . | 101 | 17 | 5 |

One may see this cost per mile stated at half this sum, but it will be found that it assumes the car to be worth the same sum at

the end of the year as when bought, and no allowance is made for interest on capital. It must be borne in mind, however, that the cost of the car in any case must be considered, for the sum has been paid away, and is a charge on the travel account. In the above there is no charge for stabling the car.

The budget for a larger car accomplishing, say, 7,500 miles per annum, will be as follows :—

| | £ | *s.* | *d.* |
|---|---|---|---|
| Initial outlay £600, depreciation at 12½ per cent. | 75 | 0 | 0 |
| Petrol at ⅔*d.* per mile | 20 | 16 | 8 |
| Lubricant at 10*s.* per 1000 miles | 3 | 15 | 0 |
| Tyres at 1½*d.* per mile | 46 | 17 | 6 |
| Repairs and renewals at ¾*d.* per mile | 23 | 8 | 9 |
| Insurance per annum | 15 | 0 | 0 |
| Wages per annum and garaging | 100 | 0 | 0 |
| Taxes | 7 | 6 | 0 |
| Interest at 4 per cent. on £600 | 24 | 0 | 0 |
| Or about 10*d.* per mile | 316 | 3 | 11 |

This sum is naturally easily reduced if the tyres are well looked after each day, the roads are good, and if the mileage is increased to, say, 10,000, no interest is charged on capital, and no servant is kept. It may be taken for granted, however, that it represents the cost for running a fair-sized car of 25 to 30 horse-power—in favourable circumstances it may possibly be brought as low as 7*d.* A large car where the initial outlay runs into four figures, usually costs from 1*s.* a mile to run, but in this case economy is not of great moment.

Bearing in mind the approximate sum arrived at, namely 5*d.* for a small car and 10*d.* for a larger one, the first represents a somewhat cheaper rate than the taxicab, and the other a rate per mile somewhat dearer, which is reasonable bearing in mind the various circumstances entailed, while the cost per passenger mile is, of course, about half that of the above figures, and depends on the average number of passengers carried.

# CHAPTER XXX

## *COMMERCIAL MOTORING AND ITS COST*

Although this book does not reckon to deal with the commercial vehicle, yet the question of the financial side of commercial motoring is of primary importance to many pleasure car owners, while at the same time the profitable running of commercial motor vehicles of all kinds is a matter which affects many who are not themselves motorists, and in the future it is quite possible that the motor van will far outnumber the pleasure vehicle in a similar proportion to that which obtained fifteen years ago in the field of horse-traction.

*The Spread of the use of Commercial Motor Vehicles.*—So far, the greater majority of motor cars are utilized for pleasure purposes, but if the mechanically propelled vehicle is to largely supplant horse-drawn traffic as a whole, then there is still an enormous field open to the manufacturer of commercial motor vehicles. Regarding public service vehicles in the big cities, the change from one form of traction to the other is almost complete, especially if the electric tramcar is included. The most striking feature regarding the recent history of omnibuses and cabs is the continually increasing numbers of motor vehicles which have been placed on the streets, together with the rapid decrease of the horsed 'bus and cab. This class of vehicle, which appeals directly to the public, has naturally an educative influence, and now that these vehicles are, in many instances, found to run well under arduous conditions, and to earn dividends, if only small ones, in some cases, the result is a gradual change of opinion of those who are potential commercial vehicle buyers.

Apart from mechanical fitness, the question of cost is a more vital one than with the pleasure car, and very often the only obstacle to the substitution of one form of locomotion for the other

is the difficulty of convincing the inquirer that his cartage bill will be less, or in any case not any greater in proportion to work done.

The commercial motor movement has progressed to that extent that it may be now asserted that all the various trades to which the motor can advantageously be adopted are represented in the list of motor owners, so that future work lies in persuading further firms in each trade to follow the example of their more courageous fellow-tradesmen. Approximately, there are about eighty distinct trades whose business operations include sufficient delivery and transport work to warrant the adoption of a speedier vehicle.

*Motor Vans favoured by Stores and General Carriers.*—The class of firm which has found the motor most advantageous is the large stores. By reason of the greater mileage which can be accomplished daily, it has been proved that the fleets of these firms are enabled to operate economically over a very wide area, which, naturally, has not been without its effect on the suburban tradesmen. These vehicles not only deliver goods more cheaply, but provide a source of advertisement in themselves in an instance where publicity is specially sought after.

Other trades, which may be taken as a subdivision of a stores, such as drapery, furnishing, provision dealing, and so on, are large customers of the motor manufacturer, and such industries where delivery is an essential feature, such as carting, parcel delivering, laundry work, and mineral water manufacturing, find the motor cheaper than horse traction.

In the instances mentioned, the petrol motor holds sway, but where heavy delivery is required, such as in the various branches of the engineering and building trades, brewery and milling trades, municipal and sanitary work of various descriptions, the steam vehicle has been adopted. Where a bulky load is made up, such as with market gardeners, a trailer and tractor are often used, a means adopted in other trades when a long round or a double load is required to be carried, and pace is not specially sought after.

The question being largely a financial one, the smaller tradesman has to consider the loss of capital through selling horses and vans, and the anxiety attendant upon having his motors carelessly handled by indifferent or unskilful drivers, and the amount of proper attention which will be given in the garage. In most cases,

the horse and van proprietor has sufficient knowledge of animals to understand at once if they are being cared for properly, but under the new state of affairs he has to largely trust his employees, and the amount of conscientiousness possessed by them largely decides the success of the motor vehicle in his particular instance.

*Possible Effect on Price of Commodities and the Welfare of Railways.*—If goods can be carried more cheaply in every trade, then it must in time have its effect on prices generally, which may not, however, mean that these articles will become cheaper necessarily; but in the face of increasing cost of labour, rent, and other expenses, it may be a factor in keeping prices stationary, or control the rate of increase.

Motor delivery enables goods to be packed at the manufactory and delivered direct at the door of the retailer, or between trader and consumer, without any intermediate handling or repacking. In many cases this means that the railway does not handle the goods at all, so that, as has been stated elsewhere, keen competition must eventually take place between road and rail goods traffic, especially for short distances. With perishable goods, quick transit may mean the difference between a small profit and considerable loss.

*The Cost of Running Analysed.*—The expense connected with running any type of car depends on several circumstances. A well-designed car—that is, one which is built strongly, has ample wearing surfaces, all details of a simple character—is the first essential, so that repairs and maintenance may be kept as low as possible, and the depreciation figure adopted shall not be underrated. The mileage covered is also important, for the cost per mile can easily be doubled if only small daily runs are carried out. Fifty miles a day may be looked upon as an all-round paying mileage, with a minimum of 200 days' run per annum. If the mileage is increased beyond 50, and runs as high as 80 to 100, then maintenance and repairs will increase per mile in some cases.

The amount of proper attention given, both on the road and in the garage, is of sufficient importance to impress on the proprietor the necessity of obtaining reliable drivers and engineers. Reports, repairs, the issuing of stores, such as fuel, lubricant, and so on, should be done systematically, so that there is as little wastage as possible in the matter of materials used. Then the motor van

itself should be fairly treated. If it runs light, the cost per ton-mile will be increased; if it runs heavy to the point of overloading, the cost of maintenance and repairs will be raised.

*Capital Outlay.*—The first cost of the motor van and all accessories will vary according to the horse power, number of cylinders, general quality, and load to be carried. The following table will give a good idea of prices ruling to-day, an average having been struck from the price lists of leading makers:—

Cost of the Chassis (Petrol).

| Load. | Number of cylinders. | Approximate H.P. | Price of chassis only in pounds with solid tyres and usual accessories. |
|---|---|---|---|
| ½ ton | 2 | 10–12 | 290 |
| ¾ ton | 2 | 12–15 | 335 |
| 1 ton | 2 | 16 | 350 |
| ,, | 4 | 16 | 425 |
| 1½ tons | 4 | 18 | 440 |
| | | 22 | 455 |
| | | 28 | 520 |
| 2 tons | 2 | 18 | 400 |
| | 2 | 24 | 435 |
| | 4 | 22 | 490 |
| | 4 | 28 | 550 |
| 2½ tons | 4 | 30 | 580 |
| 3 tons | 4 | 25 | 580 |
| ,, | 4 | 35 | 650 |
| 4 tons | 4 | 30 | 640 |
| ,, | 4 | 40 | 700 |
| 5 tons | 4 | 30 | 700 |
| | | 35 | 725 |
| | | 40 | 750 |
| | | 50 | 775 |
| 6 tons | 4 | 32 | 750 |
| 7 tons | 4 | 35 | 760 |

*Cost of the Body.*—To the prices in column 4 of the table given must be added the cost of the body. The following may be taken as a guide to the prices of some leading types of bodies:—

| | £ |
|---|---|
| Delivery van body up to 1 ton | 40—65 |
| Large delivery van body | 60—90 |
| Lorry body with sides | 30—50 |
| ,, ,, tilt | 50—75 |
| ,, ,, plain platform | 20—45 |

A complete steam vehicle with load costs usually between £500 and £600.

*Interest on Outlay.*—This may be reckoned at 5 per cent., slightly higher than necessary, but it allows for deficiencies in other items. Some would prefer to put this item at 3–4 per cent.

*Depreciation.*—This is based on an estimate regarding the life of the vehicle. A new one of good make is generally reckoned to last from 5 to 6 years. A motor van will last 5 years if it is well cared for, and the repairs are carried out with a generous hand. In this case 20 per cent. of the capital outlay would be charged each year to the cost of running the vehicle. Depreciation may also be reckoned according to mileage, but this is difficult to compute beforehand.

*Insurance.*—It is usual to insure the van against damage, personal claims, and so on. This will vary according to the wording of the policy, and the value and horse-power of the car. The annual premium runs from £9 to £15, so that £12 may be taken as a fair average.

*Wages.*—The wages of the ordinary horse carman were notoriously low, considering the long hours often demanded, and the constant responsibility. To add to this the care necessary to control and maintain a motor van, and to expect the work to be done for the same money, is to court failure. A good driver who will also do most of his own small repairs, can seldom be obtained under 35*s.* per week, while a good mechanic is worth 50*s.*, and will soon justify his wage bill in the saving of repairs.

*Fuel and Lubricant.*—Petrol, oil and grease will be according to mileage, state of roads, efficiency of the car and the driver, and the control of the stores. Large firms can reduce this item by purchasing in bulk.

*Storage.*—The cost of housing the car will vary according to its size and locality. From 8*s.* to 12*s.* per week, per car, is a fair average.

*Tyres.*—This item will often equal the wages bill. Tyres can be obtained on a 10,000 mile guarantee basis, and with careful driving a tyre will last even longer.

*Repairs.*—This is a widely varying item, and is the deciding

factor very often in the economical working of the car. Some put it at 7½ per cent. of the capital outlay per annum, reckoning it just half the depreciation value. One largely influences the other. On the other hand, the two items may be lumped together as 25 per cent. of the capital outlay. This figure may be looked upon as a safe one when the van is looked after with care, and under systematic treatment.

*Extras.*—To the capital outlay may be added the cost of registering the vehicle, while the driver will provide his own 5*s.* licence. With public service vehicles the taxes are a considerable item.

*Cost per Mile.*—Cost per car mile is the expenditure in running the van per mile run without regard to the load carried; per ton mile, which is the fairest comparison, reckons the weight carried, and therefore bears a direct relationship to business done. It is therefore obvious that goods are transported more cheaply if the van is kept as fully loaded as possible on all occasions, and that a bulky load of inexpensive goods does not pay for cartage so well as a more compact class more valuable per unit of cubic area.

| Load carried. | Daily mileage. | Weekly mileage. | Annual mileage. | Days run per annum. | Cost in pence per ton mile. | Motive power. |
|---|---|---|---|---|---|---|
| ½ ton | 65 | 355 | 18,500 | 285 | 7 | petrol |
| ¾ ton | 65 | 340 | 17,875 | 275 | 6½ | ,, |
| 1 ton | 60 | 310 | 16,000 | 270 | 5¼ | ,, |
| 1½ tons | 60 | 300 | 15,600 | 260 | 5 | ,, |
| 2 tons | 60 | 290 | 15,300 | 255 | 4¾ | ,, |
| 2½ tons | 55 | 265 | 13,750 | 250 | 4½ | ,, |
| 3 tons | 50 | 240 | 12,500 | 250 | 4¼ | ,, |
| 4 tons | 50 | 240 | 12,500 | 250 | 4 | ,, |
| 4 tons | 40 | 190 | 10,000 | 250 | 3¾ | steam |
| 5 tons | 50 | 240 | 12,500 | 250 | 3¾ | petrol |
| 5 tons | 35 | 170 | 8,750 | 250 | 3 | steam |
| 6 tons | 45 | 215 | 11,250 | 250 | 3½ | petrol |
| 6 tons | 35 | 170 | 8,750 | 250 | 2 | steam |
| 1 ton | 16 | 100 | 4,800 | 300 | 6¼ | horse |

The above costs are somewhat on the high side, and they will be reduced when the mileage is increased, and there is a large fleet, and good management. For instance, a petrol van run five hundred miles a week will probably cost only half the figures stated. It is possible to enter into contracts whereby the maker keeps the vehicle

in running order for a fixed charge, usually in the neighbourhood of 16 to 18 per cent. of the capital outlay.

On the whole, steam traction is the cheaper, but with the heavier vehicle it is slower. The use of a tractor and trailer allows of the carriage of a larger load, but this is counterbalanced by the necessity of having to pay an extra attendant, and the capital and maintenance charges of the trailer.

Motor omnibuses have to bear a higher proportion of wages. From 7*d.* to 9*d.* may be reckoned as the cost per car mile. A double-decked bus is a 3-ton vehicle, doing a maximum mileage. Taxi-cabs, when well managed, cost about 5*d.* a mile to run.

*A List of Trades using Motor Vehicles.*—The following trades find light and medium weight vehicles of service.

Athletic Outfitters.
Wholesale Bakers and Confectioners.
Beer Bottlers.
Bicycle Dealers.
Brush Makers.
Builders, and Builders' Merchants.
Cartage Contractors and Parcel Delivery Companies.
Clothiers.
Dairy Supply Companies.
Drapers.
Dyers and Cleaners.
Fire Brigades.
Grocers and Stores.
Laundrymen.
Newspaper Proprietors and Wholesale Agents.
Printers and Stationers.
Refreshment Contractors.
Tailors and Clothiers.
Tobacco Merchants.

The heavier class of vehicle is used by—

Ammunition Manufacturers.
Billiard Table Manufacturers.
Boiler Makers.
Bottle Manufacturers.
Brewers.
Brick and Tile Makers.
Builders, Shopfitters, and Builders' Merchants.
Butchers.
Cabinet Makers.
Cotton and Woollen Goods Manufacturers and Merchants.
Cartage Contractors.
Carpet Cleaners and Manufacturers.
Chemists, Manufacturing.
China, Glass and Pottery Makers.
Coal Merchants.
Colour and Varnish Makers.
Corn and Flour Merchants.

Electrical Goods Manufacturers.
Engineering Trades, various.
House Furnishers and Removers.
Jam Makers.
Market Gardeners.
Match Makers.
Mineral Water Manufacturers.
Motor Car Manufacturers.
Municipal Contractors.
Paper Makers.
Pianoforte Makers.
Railway Companies.
Soap Makers.
Timber Merchants.
Wine Merchants and Distillers.

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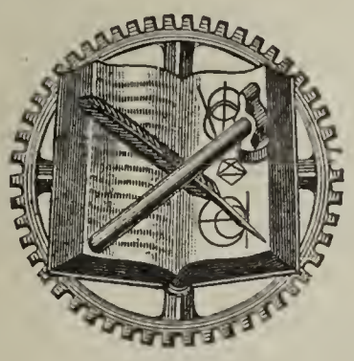

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